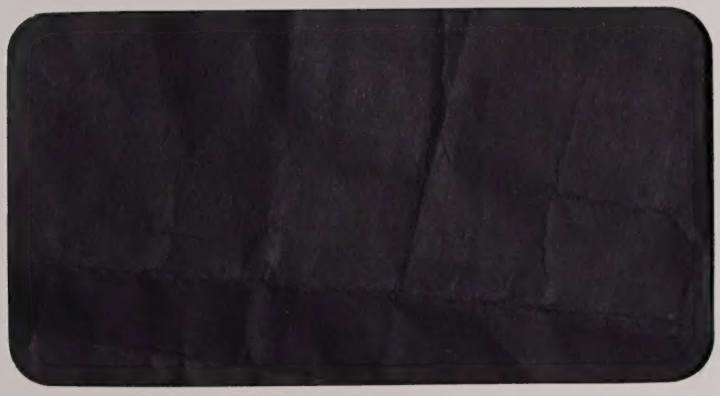

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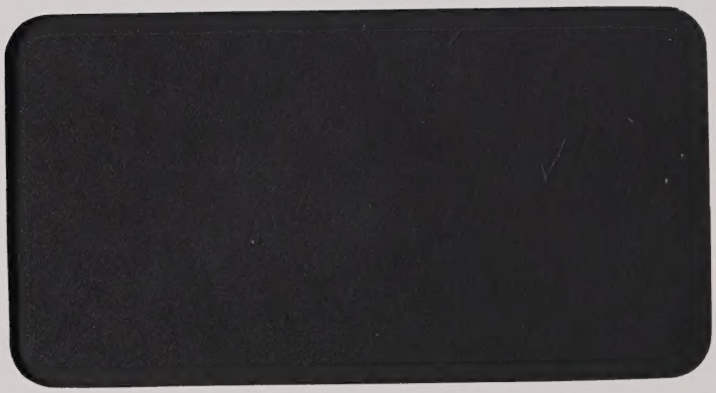

Gould 4070 Series
Digital Storage Oscilloscopes
Operators Manual

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Introduction

NOTE: This is a combined operating manual for the 4071 and 4072 2-Channel and the 4074 4-Channel Digital Storage Oscilloscopes.

Throughout the operating manual the following convention applies:–

4070 – refers to the 4071, 4072 and 4074.
4071 – refers to only the 2 channel 4071.
4072 – refers to only the 2 channel 4072.
4074 – refers to only the 4 channel 4074.

Gould's 4070 series of digital oscilloscopes have been designed with the user in mind. These highly sophisticated instruments are particularly easy to use.

To obtain a trace is especially simple – just connect the signal and press the Auto Setup button – the 4070 does the rest. Having obtained a trace, three readily accessible cursors make it easy to take timing and voltage measurements directly from the screen. The built-in plotter or an external plotter using HPGL can be used to make a hard copy of the display for future reference as well.

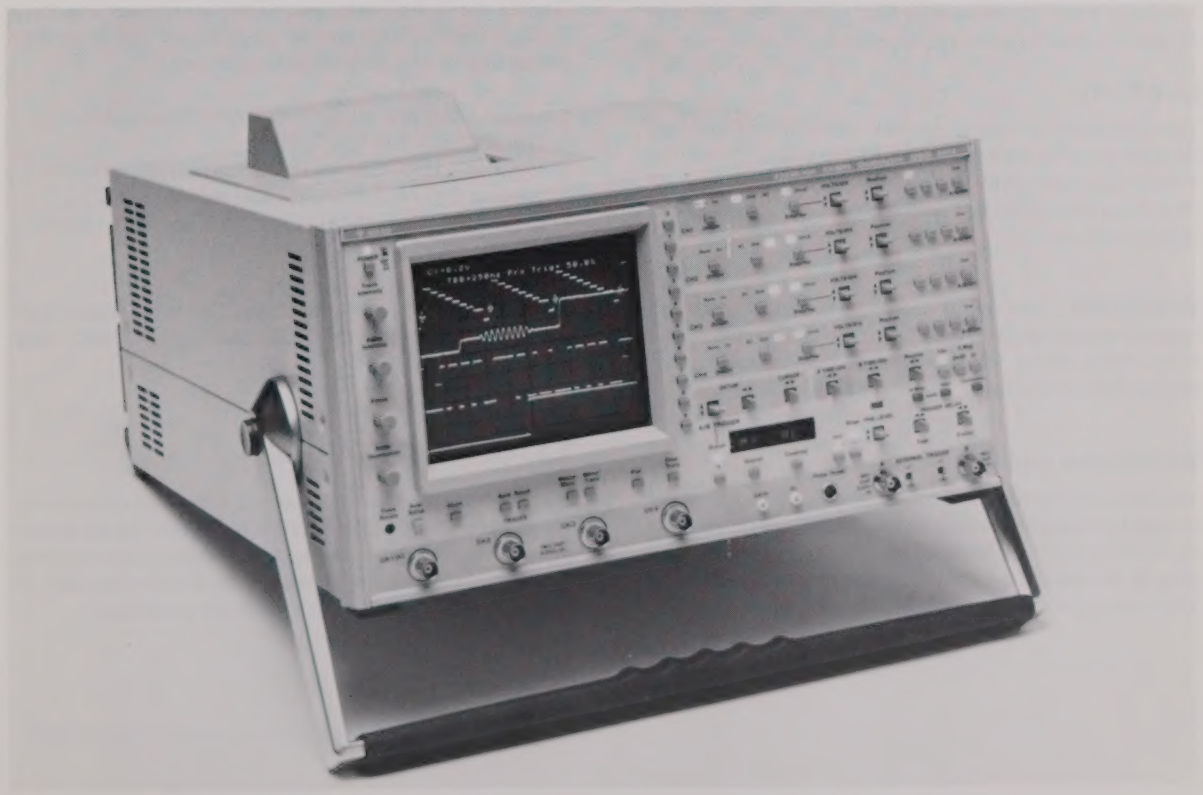
For the more advanced user, the 4070 series have a great deal to offer. The GPIB(IEEE488) and RS423(RS-232) interfaces, allow control by a computer, hence the oscilloscope can be left unattended whilst it continues to take measurements and plot traces as and when required. All of the operating functions can be controlled by the computer and the oscilloscope can output complete trace data to the computer for further analysis.

The 4070 incorporates a software menu system allowing functions to be easily accessed. For example, up to four control setups including attenuator, trigger, GPIB and RS423 settings can be stored in battery-backed memory for future use with the 'Save and Recall Setups' menu.

The trigger menu allows the 4070's triggering system to be controlled using a 'Trigger Configuration Diagram'. This is designed to mimic the way that most users think about complex triggering requirements. It displays a flow diagram allowing various conditional triggering options to be set and combined appropriately. Options include event counting, time delays, and trace B to wait for triggering on trace A.

The Display menu allows control of some of the 4070's most advanced facilities. For example, using this menu, it is possible to select the glitch detection function. This can be used to detect transients as brief as 5ns even on the slowest timebase ranges. It is also useful for alias detection in certain circumstances. Another option, particularly useful when a trace has been magnified in the X direction, is interpolation. The 4070 is able to perform rapid sine interpolation on captured signals. Points are calculated and inserted between the actual samples which make up the originally captured trace. The original trace data is not lost and the uninterpolated display can be retrieved at any time. The 4070 can also perform linear interpolation if required.

The oscilloscope is also fitted with a keypad interface, allowing Gould waveform processors to be connected to provide extra functions. These include automatic measurement of risetime, overshoot and frequency.



1.0 SAFETY AND POWER REQUIREMENTS

Safety Warning

(as required for I.E.C. 348 Class I)

This instrument manual contains information and warnings which must be observed by the user to ensure safe operation and retain the apparatus in a safe condition. The instrument has been designed for indoor use within the specified limits of temperature, i.e. 0 to 50 deg. C. It should not be switched on if there are obvious signs of mechanical damage and it should not be used under wet conditions.

Grounding

The instrument must be operated with a protective ground connected via the appropriate (yellow/green) conductor of the supply cable. This is connected to the instrument before the line and neutral supply connections when the supply plug is inserted into the socket on the back of the instrument. If the final connection between this and the supply is made elsewhere,the user must ensure the ground connection is made before line and neutral.

If any supply cable other than that supplied with the instrument is used, it must carry an adequate protective ground conductor.

Any interruption of the protective ground conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

Signal connections into the instrument should be connected after and disconnected before the protective ground connection is made, i.e. the supply lead must be connected at all times that signal leads are connected.

Live Parts

The instrument is safe to operate with covers fitted and these must not be removed under normal usage. The covers protect the user from live parts and they should be removed only by suitably qualified personnel for maintenance and repair purposes.

WARNING: *Removing the covers may expose voltages in excess of 2000V, in particular at the rear of the tube, even when the instrument has been disconnected from the power source for some time.*

Ventilation and Dust

The instrument relies on fan assisted cooling and must not be operated in a position which restricts air flow through the air intake in the back of the instrument and the ventilation slots in the sides. The instrument should not therefore be used in a tightly fitting rack as this will limit ventilation. Adequate ventilation can usually be achieved by leaving an 8cm gap around the top, rear and sides of the instrument.

The instrument should not be operated in dusty environments.

Operating Temperatures

The instrument is designed to be operated in an environment having an ambient temperature of between 0 deg. C and 50 deg. C. The instrument is only guaranteed to operate with full accuracy within a temperature range of 15 deg. C to 35 deg. C.

Note: The use of the instrument in strong direct sunlight or next to radiators and other heat sources may markedly increase the temperature of the instrument and this should be taken into account when assessing the viability of using the instrument in a given environment.

Power and Frequency Requirements

The instrument is designed to consume less than 200W and operate from supply voltages of between 90V and 265V, without any need for mains tap switching.

It will operate at supply frequencies of between 45Hz minimum and 440Hz maximum.

Under the extreme conditions of 90V and 45Hz, the instrument will still operate properly even if there is a half cycle dropout in the mains supply.

Fuse Requirements

Despite the fact that the instrument operates at less than 200W, it draws a large current on power-up and so the following fuse arrangement must be followed:

* one 4A HRC fuse on the rear panel; (Gould part no. 457032)
* one 3.15A HRC fuse inside the instrument, under the panel at the rear left side (Gould part no. 456327).
* for instruments in the U.K. one 13A fuse in the mains supply plug;

Note: *The HRC (High Rupturing Capacity) fuses must not be replaced by normal fuses. Use HRC or HBC fuses rated to break at 1500A.*

1.1 GETTING STARTED

This section of the manual is aimed at the first-time user of the 4070 oscilloscope. It describes how to set up the instrument and how to go about displaying a signal. Later sections of this manual will cover many of the features mentioned here in greater detail and at a more advanced level.

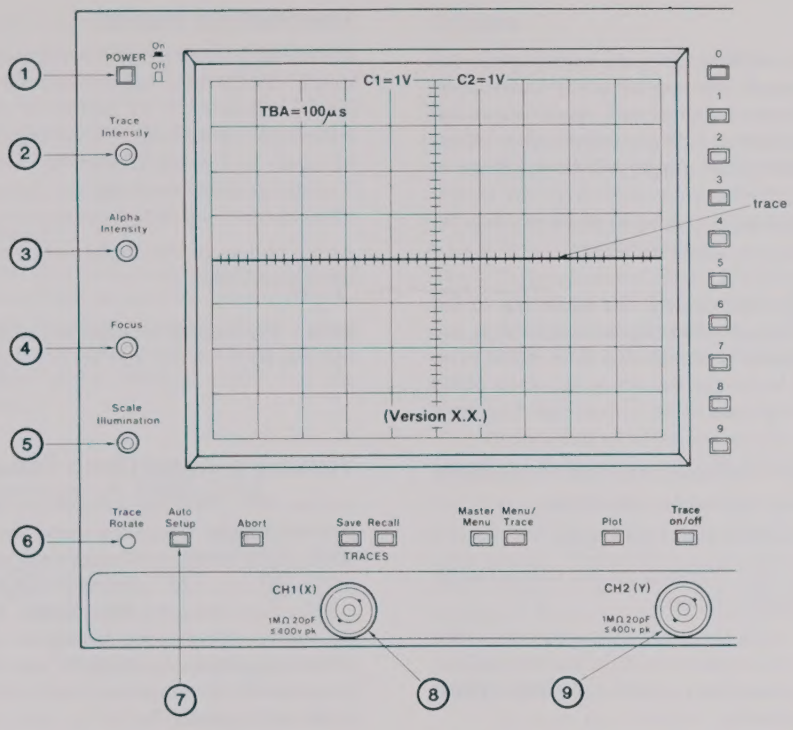


Figure 1.1.1 Power-on Display (4071 & 4072)

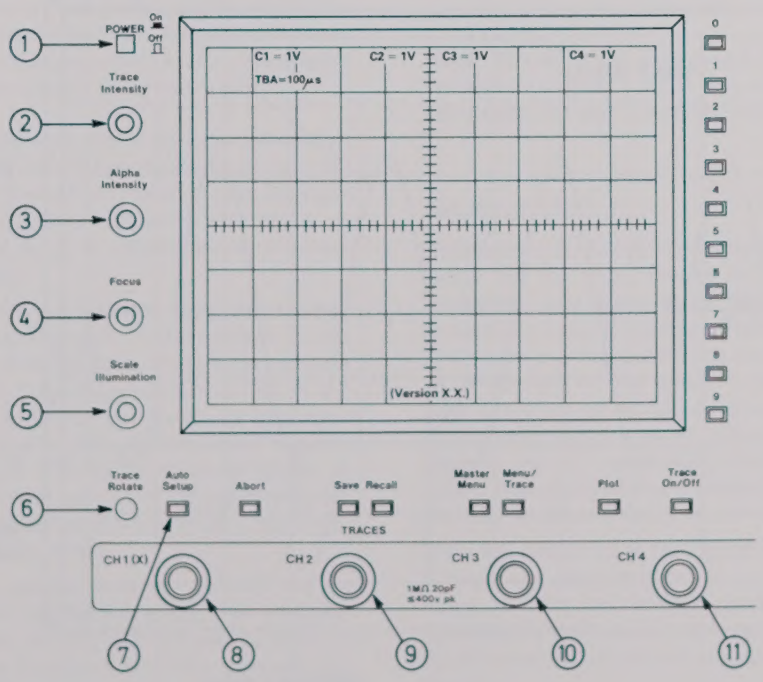


Figure 1.1.2 Power-on Display (4074)

Power On (1)

After connecting the oscilloscope to the supply, press the POWER button situated in the top-left corner of the front panel of the oscilloscope. A light should appear above the button. After the automatic calibration procedure which takes less than a minute, the display will be as shown in Figure 1.1.1.

The display may need some adjustment. The following rotary controls can be used to adjust the display.

Trace Intensity (2) This controls the brightness of the 'trace', i.e. of the part of the display used to show any signal. At the moment, the trace will be visible as an approximately horizontal line across the centre of the display. The brightness of the cursors and the trigger level indicator are also adjusted by this control.

Alpha Intensity (3) This is used to control the brightness of the characters displayed on the screen.

Focus (4) Controls the focus of the display.

Scale Illumination (5) The grid on the screen can be illuminated using this control.

Trace Rotate (6) If the trace with input grounded is not properly horizontal relative to the scale, then adjustment of this control with a small screwdriver allows this to be corrected.

The Start-Up Display

4071 & 4072 – Apart from the trace across the centre of the screen, several other features are visible on the display. At the top will be 'C1 = 1V' and 'C2 = 1V', or similar. This is referring to the two signal inputs, channel 1 and channel 2, which are both in this case set to 1 Volt per vertical screen division (graticule marking); i.e. an applied signal of 1V in either channel will deflect the trace by one screen division.

At the bottom of the display is the version number of the internal software.

4074 – This display is similar to the 4072 except that there will also be 'C3 = 1V' and 'C4 = 1V' or similar.

Viewing a Signal (Auto Setup)

On the 4070, obtaining a display of an input signal is particularly simple. Connect a signal (less than plus or minus 400V peak) to the oscilloscope via any input socket (for 4072 (8) or (9), for 4074 (8), (9), (10), or (11)) and press the **Auto Setup** (7) button. Assuming you've applied a regular signal, say a 4kHz sine-wave with an amplitude of perhaps 5V peak to peak, it will almost immediately be represented on the display. An example is shown in Figure 1.1.3.

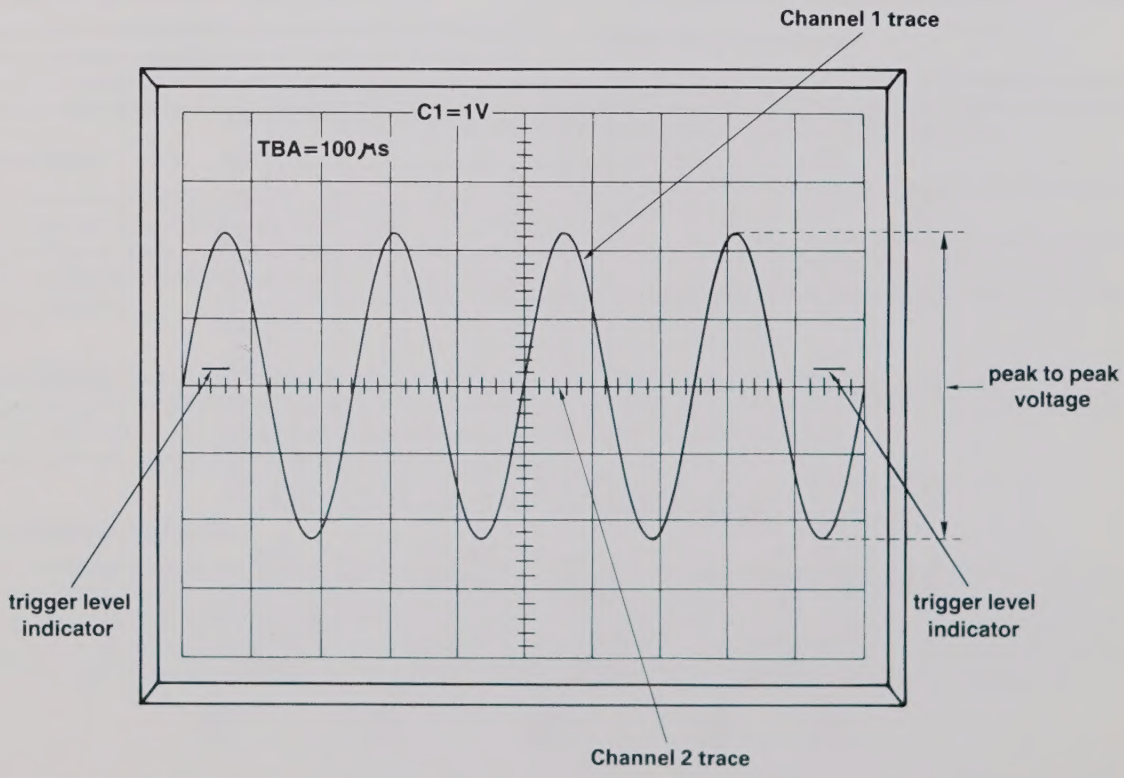


Figure 1.1.3 An Auto Setup Display

Auto Setup (7) will always attempt to arrange the display so that two to five complete cycles appear, with the amplitude set so that the height of the trace is roughly two to five screen divisions. It also selects auto trigger to ensure that the screen is frequently updated and a trace will be visible.

Adjusting the Trace

The trace can be altered in two main ways: horizontally and vertically. Basic horizontal adjustments involve altering the sweep rate of the trace, so that the image on the screen stretches or contracts horizontally. The main vertical adjustment is the height of the displayed signal - i.e. the volts per screen division.

Horizontal Adjustment (A TIME/DIV)

To alter the sweep rate of the trace, for example to look more closely at part of the image, the **A TIME/DIV** paddle is used (the **B TIME/DIV** paddle is discussed in Section 1.3.). With the 4kHz signal applied as discussed earlier, Auto Setup may have set the sweep rate to 50μs per screen division horizontally - i.e. each horizontal screen division represents 50μs worth of the input signal. This is shown by the 'TBA=50μs' near the top of the display. The 'TBA' means that the A timebase is in use; two timebases are available for each channel, namely A and B. Use of the B timebase is discussed in Section 1.3.

A TIME/DIV (3) This is a five position paddle which controls the sweep rate of the trace. A gentle push causes a slow change in the sweep rate, whilst a firmer push will cause a faster change in the sweep rate.

Given that the current sweep rate is 50μs per screen division, a single push and release of the paddle to the right will change the 'timebase' from 50μs per division to 20μs per division. The displayed signal will stretch accordingly. A second single push to the right will change the timebase again, this time to 10μs.

If you keep pushing the paddle to the right, you will find that the fastest timebase is 20ns per screen division. On the 4071 operating in dual channel mode, the 250ns per division range is not available. You may notice that at 100, 50 and 20ns per division, the oscilloscope builds up the image gradually. This is because it uses a method called 'Equivalent Time Sampling' or ETS for the faster timebases. It takes a number of random samples of the signal and adds them to the display to build up the final result. This is only useful for repetitive input signals.

If you now push the paddle to the left you will see the timebase change in the opposite direction. The maximum time per division is 20s; the 4070 will take over 3 minutes to acquire a full trace at this speed. However, assuming you are applying the 4kHz signal mentioned earlier, when the timebase reaches 50ms, an 'alias' becomes visible.

Aliases

An alias is a false image. The 4070 is a digital oscilloscope and so takes frequent samples of the input signal in order to update the trace. Thus it may take one sample from one point on the input waveform and the next sample from a point slightly further along on the next wave. It will then display the wave as being much longer than it really is. The effect is similar in principle to the false motion of wagon-wheels as seen on a television.

The 4070 does however have a feature which will often help you to spot aliases. If the input signal peaks or troughs at any point between samples, a peak/trough can be displayed. This Max-Min function is discussed further in Section 2.4.

Vertical Adjustment (VOLTS/DIV)

Each of the channels has its own set of vertical controls. The main control in each case is the **VOLTS/DIV** (volts per division) paddle. Again this is a five-position switch. A gentle push either up or down will result in a slow single step change in the sensitivity of the instrument. A firmer push will cause a more rapid change.

VOLTS/DIV (2) This is a five-position paddle. It adjusts the volts per division. Pushing the paddle upwards will adjust the sensitivity as far as 5V/div and the height of the image will be seen to decrease in accordance with the changes. In the other direction, sensitivity can be increased as far as 2mV per division, increasing the height of the screen image.

Note: *The 4070 can accept input signals with a peak voltage as high as plus or minus 400V. Larger signals can cause damage to the internal circuitry.*

AC/Gnd/DC (1)

This button controls the type of coupling between the input signal and the 4070. Though DC is the most generally applicable, auto setup will normally set this control to AC to facilitate sensible triggering. However, if when using the instrument you find that there is a permanent vertical offset in the display - i.e. the signal is consistently displayed too high or too low on the screen - you could try pressing this button once to set it to AC. This will cause the 4070 to remove any DC component which may be causing the offset. Repeated pressing of this button will cause it to cycle through the three settings AC, Ground and DC.

With this control set to DC, the 4070 can display signals in a frequency range of 0Hz(DC) to 100MHz. On AC, the range is 10Hz to 100MHz. With the setting on Gnd (ground) a 0V reference only is displayed (the input signal is not connected to ground or coupled to the trace in this case).

This control is discussed in more detail in Section 1.2.

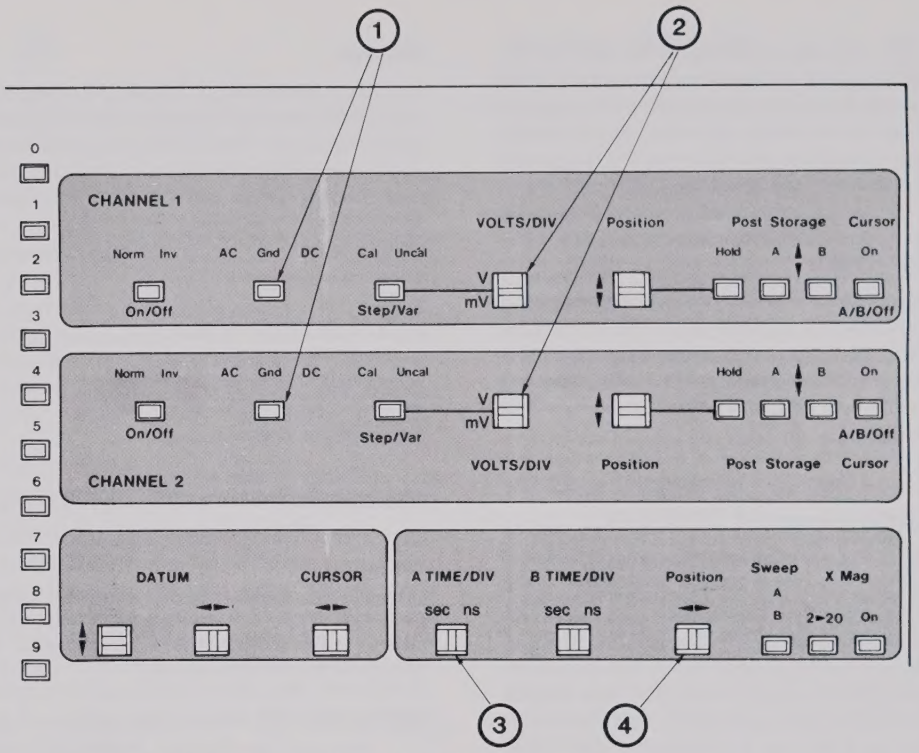


Figure 1.1.4 Horizontal & Vertical Controls (4071 & 4072)

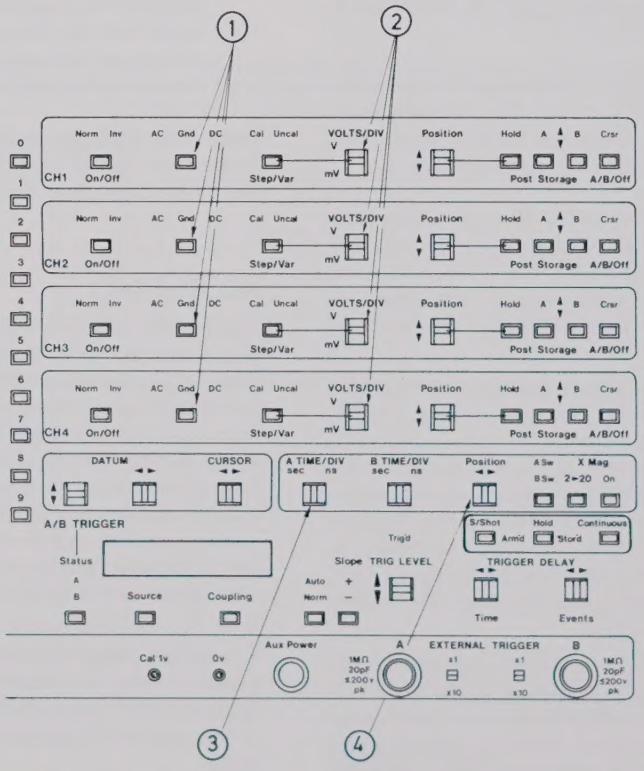


Figure 1.1.5 Horizontal & Vertical Controls (4074)

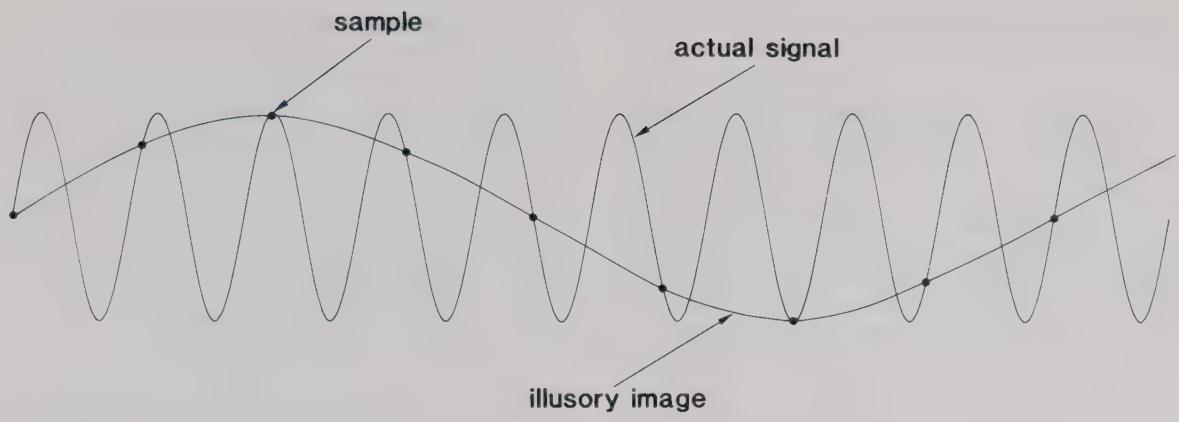


Figure 1.1.6 Alias Generation

Operating Hints

The following list gives some of the more commonly met problems in operating digital oscilloscopes, how to correct them, and a brief explanation of what was wrong.

You may need to consult later sections of the manual as not all the operating features have been discussed so far.

Problem: No trace visible.

Trace intensity too low	- Correct with Trace Intensity Control. Turn on other trace.
No stable trigger	- Select Auto Trigger until trace found.
Too much vertical shift	- correct with the vertical Position paddle.
Too much post storage shift	- cancel post storage shift.
Input has large DC offset	- AC couple input signal. - correct with position paddle. - use a less sensitive range.

Problem: Trace not being acquired.

Trigger level incorrect	- select AC coupling, AUTO and AC trigger, then adjust the level control until the trigger level 'bars' are lined up with the centre of the trace.
Trigger source on the wrong input	- change trigger source.
Trigger coupling on an unsuitable setting	- change trigger coupling.
Hold on	- release Hold.
Timebase on very slow acquisition	- adjust timebase speed.
Insufficient signal to trigger on	- use Auto Trigger.
Instrument in single capture mode	- press Continuous.

Problem: Trace is unstable even when triggered.

Alias	- check for alias with max-min glitch detect and select a faster timebase range.
Noisy input	- select DCLP or ACLP trigger coupling. - select bandwidth limit. - adjust trigger level.
Trigger on AUTO	- With low frequency inputs, below 40Hz, AUTO trigger will not work correctly. Select Normal trigger.
Input non-repetitive	- Select NORM trigger mode and S/Shot.
Input has many non-identical trigger points	- use divide by N.

Problem: Trace has a very flat top or bottom.

Trace captured when in limit and post storage shift has been used.	- adjust pre-storage shift. - use less sensitive range.

Problem: Trace is very 'dotty'.

Too much horizontal expansion	- decrease expansion. - use linear or sine interpolation. - re-capture on a faster timebase range.

1.2 VERTICAL POSITION AND ATTENUATORS

Each of the channels has its own set of controls: among other things, these adjust its sensitivity to input signals and the vertical position of its trace (or traces if both the A and B timebases are in use - see below). The controls are shown in Figure 1.2.1

The channels are identical in all respects except when used in 'X-Y mode'. In the 4071 & 4072, channel 1 is used to control the X (horizontal) component of the trace, channel 2 controls the Y (vertical) component. The 4074 also uses channel 1 to control the X (horizontal) component of the trace and channels 2, 3 and 4 separately control the Y (vertical) components.

Channel Selection (1)

A channel may be switched on or off with its On/Off button. If the channel is on, its trace can be displayed in either normal or inverted mode. The channel status is shown by the illuminated letters above the button: if both lights are out, then the channel is off.

The three options Norm/Inv/Off are selected by sequentially pressing this button.

Norm The trace is a true representation of the input signal.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen. If DC coupling is in use, see the following section.

Input Coupling (AC/Gnd/DC) (2)

The coupling of the signal to the 4070 is chosen using the **AC/Gnd/DC** button, the current setting being shown by the illuminated letters above. Repeated pressing of the button causes the selection to cycle through the three options.

AC This is used for rapidly varying input signals. Low frequency and DC components will be removed. Suitable input signals (i.e. the bandwidth) are from 10Hz to 100MHz with a x1 probe or direct input, and 1Hz to 100MHz with a x10 probe.

Gnd The input signal is not coupled to the instrument. A 0V reference signal is displayed.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth will normally be from DC to 100MHz (see 'Bandwidth Limit' in Section 2.4).

The input impedance is 1MOhm in parallel with a capacitance of 20pF for all 3 selections.

Sensitivity (Step/Var) (3)(4)

The VOLTS/DIV paddle controls the sensitivity of the channel attenuator - i.e. it controls the amount by which the trace is deflected for a given input signal. The Step/Var button determines whether it does this in discrete steps or continuously over a limited range. The current sensitivity is shown in the top line of the display. The ">" symbol is

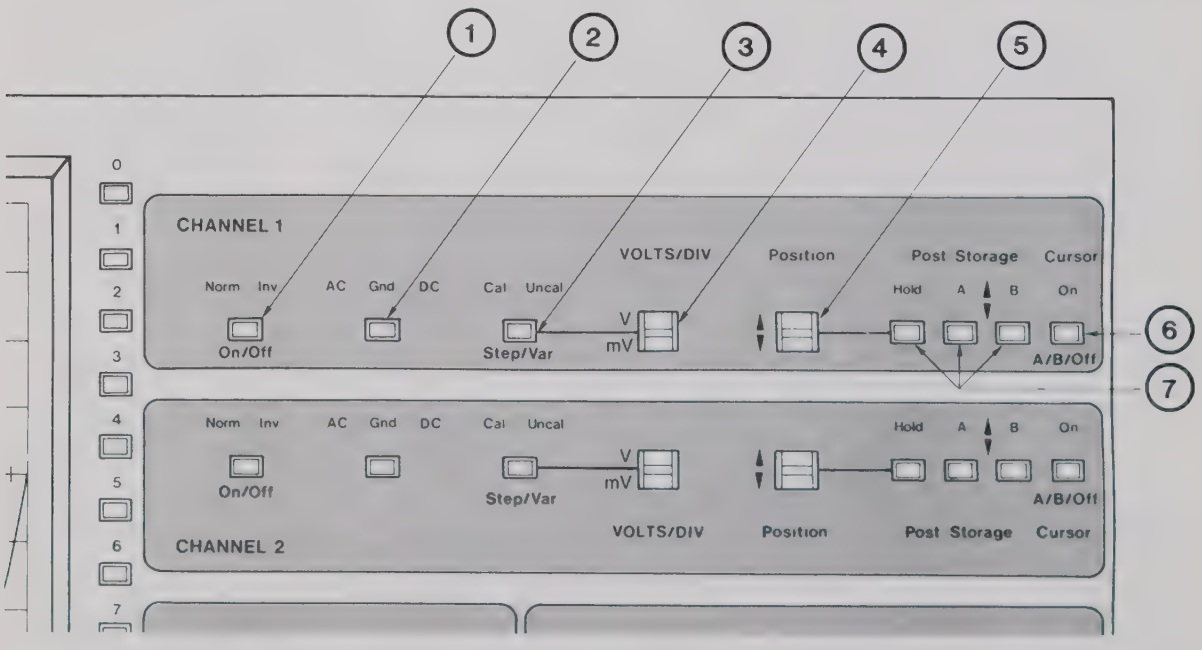


Figure 1.2.1 The Vertical Controls (4071/4072 shown – 4074 is similar)

shown in front of the attenuator setting when variable is used. Also,when switching between Cal and Uncal the variable setting is memorised so that the 'Uncal' ratio can be recalled.

Example screen display:

C1=5V Channel 1 is set to a sensitivity of 5 volts per screen division.

C2>20mV Channel 2 is uncalibrated and the attenuator is set to a reduced sensitivity. (i.e. greater than 20mV per screen division.)

The status of the **Step/Var** button is indicated by the illuminated letters above the button. Depending upon this, the **VOLTS/DIV** paddle will operate as follows:

Cal When Cal is illuminated the paddle steps the attenuator through the discrete calibrated ranges from 2mV to 5V per screen division in 1, 2, 5 steps. With a x10 probe the ranges are 20mV to 50V per division at the probe input.

Uncal The coarse setting of the attenuator remains unchanged, but a variable gain is applied to the input signal. This gain has a range of 1 to about 0.4. Thus, with an initial setting of 1V, the actual sensitivity of the channel could be set by the paddle to anywhere between 1V and 2.5V per division.

Note: *If the Gould PB36 x10 probe is used, it will be detected and the correct sensitivity will be displayed.*

Position (5)

The **Position** paddle controls the vertical position of the trace(s) for its channel. It has the following settings: Fast up, slow up, no shift, slow down and fast down.

If either of the A or B Post Storage lights are lit, then the **Position** paddle will apply 'post-storage shift' to the relevant trace(s). The paddle will move the trace in the same way as before. When the light is off, the trace will return to its original vertical position. This shifted position is memorised and can be recalled later by switching the light on again. When post-storage shift is used, any part of the trace which would have been off-screen at the ADC limits will be replaced by a horizontal line.

Post Storage (7)

The three Post Storage buttons, **Hold, A** and **B,** are used for freezing a trace and determining which traces may be affected by the **Position** paddle:

Hold Freezes the trace on the screen the moment it is pressed. In dual timebase mode, both traces will be held. It is not possible to have one timebase held whilst keeping the other one live.

A Pressing this button switches the A light on and off. When the A light is illuminated, the **Position** paddle will add post-storage shift to the A trace.

B Pressing this button switches the B light on and off. When the B light is illuminated, the **Position** paddle will add post-storage shift to the B trace.

Note: *Post-storage shift is only available on live traces when in dual timebase mode, when it is useful for producing trace separation. Post-storage shift may be added to traces in single timebase modes, but only when held.*

Cursors (6)

The cursors may be called onto any channel by pressing the respective channel's **Cursor** button. If only one timebase is in use then the cursors will go onto the only displayed trace. In dual timebase mode, the cursors will initially appear on trace A; a second press of the button will transfer them to the B trace. A third press of the button switches the cursors off.

For a full description of cursor operation, see Section 1.6.

1.3 HORIZONTAL POSITION AND TIMEBASE

The controls discussed in this section allow the trace to be moved sideways, magnified (i.e. stretched), and observed at widely varying sweep rates, allowing signals of greatly differing characteristics to be examined with equal ease.

Timebase Settings (1)

The two timebases which are available for the input signal are set by the **A** and **B 'TIME/DIV'** paddles. As with all the paddles, these are five position switches; they control the rate at which the timebase is changed.

Moving either of the paddles to the left reduces the sweep speed (acquisition rate) for that trace. When 20 seconds per division is reached, further leftward presses will be ignored. Moving the paddle to the right increases the sweep speed, up to a maximum of 20ns/div (see 'Equivalent Time Sampling' below). The paddles change the timebase in 1, 2, 5 steps.

One of the special features of this oscilloscope is its ability to display the input signals alternately on two independent timebases. For example, it is permissible to display the A trace with its timebase set to 1ms/div and then display the B trace with its timebase set to 20μs/div. Visually of course, the alternation is so fast that no flickering is visible.

Note: *The fastest non-ETS (see below) capture rate is 250ns per division. This range is not available on the 4071 when both input channels are in operation. There is no 200ns/div range.*

Equivalent Time Sampling

The three fastest timebase ranges, 100, 50 and 20ns/division, are produced by Equivalent Time Sampling, or ETS.

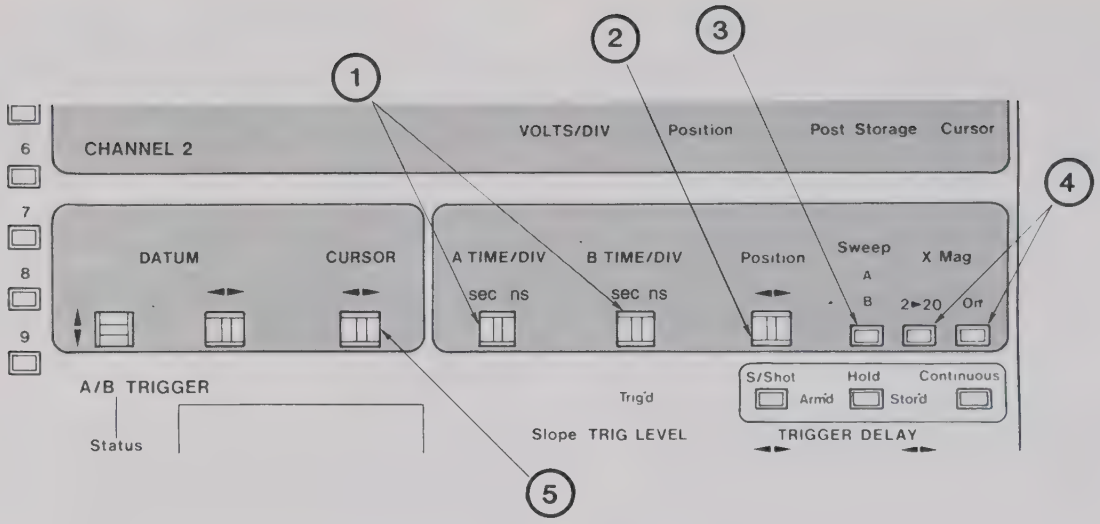


Figure 1.3.1 The Horizontal Controls (4071/4072 shown – 4074 is similar)

This is a random sampling scheme whereby the trace is built up over several captures, each of which contributes only a small fraction to the final picture. Clearly, for this to produce a meaningful trace, the input signal must be repetitive and accompanied by a stable trigger.

The number of captures required to build up a trace is variable, but in general the faster timebases require more captures.

The fastest timebase, 20ns/div, is equivalent to a sampling rate of 5GHz, giving 50 samples per cycle on a 100MHz input signal.

Note: *ETS on the 4070 allows captures with pre-trigger; i.e. it allows the user to examine events prior to the trigger point. This is discussed in Section 1.4.*

Selecting a Timebase (3)

There are three possible timebase options: A only, B only and A & B alternately. Selection is made with the **Sweep** button; the choice is shown by the illuminated lights above the button.

Sweep Repeated pressing of this button cycles through the possible combinations of the timebases: A only, A & B alternately, B only. A further press returns the selection to A only, etc.

A A only. Any active channel will acquire and display a single trace on the A timebase setting.

B B only. Any active channel will acquire and display a single trace on the B timebase setting.

A B A and B alternately (i.e. 'dual timebase mode'). Any active channel will acquire and display two traces: one on the A timebase setting alternating rapidly with one on the B timebase setting.

In dual timebase mode (A & B traces both in use), both traces will be acquired from the same vertical channel (1 or 2). Thus they may appear superimposed on the display; as a result the A trace may appear brighter. To separate them, post storage shift can be used; see Section 1.2 for more about this.

X Magnification (4)

The **X Mag On** button is used to switch on the X or horizontal magnification facility. When selected, the initial expansion applied defaults to the last used setting. If the feature has not been used since power-up, the x10 expansion is selected. The timebase setting is adjusted to reflect the amount of expansion set.

When magnification is applied, the trace expands around the present centre of the screen. On each pressing of the **X Mag 2►20** button, the trace will expand again around the presently displayed centre, up to a maximum of x20.

Note: x10 is the maximum expansion on 20ns/div range.

X Mag On Selects X magnification; if it is already selected, pressing again switches it off.

X Mag 2►20 Selects the amount of expansion applied to the trace. Each press of the button steps the magnification through the settings x2, x5, x10 and x20. After x20, a further press returns the setting to x2. The new timebase range is displayed each time the button is pressed.

In its normal mode, the 4070 displays 100 dots (samples) per screen division. As more magnification is applied, the individual dots become more obvious until at x20 there are only 5 dots per division. There are several ways of improving the picture: using the dot joining facility; linear interpolation; or sine interpolation. These advanced features are discussed in Section 2.4.

Trace Position (2)

The **Position** paddle is used to move the trace to the right and left. The paddle has five settings: fast right, slow right; no shift; slow left; and fast left. In addition, after a few moments on the fast settings the rate of shift accelerates.

The position of the cursors (see Section 1.6 for more about these) is fixed in relation to the trace and they will move with the applied shift. With X magnified traces, the cursors can be off-screen. To bring them back into view it is necessary to use the **CURSOR** position paddles.

1.4 BASIC TRIGGER CONTROL

The trigger facilities offered by the 4070 are very comprehensive; those discussed here are controllable directly from the front panel. For the more advanced menu-controlled facilities, see Section 2.3.

The default setting of the instrument on first power-up is as follows:

> The A trigger will be set to initiate captures on the A & B timebase ranges.

Selecting Source and Coupling

The two trigger channels A and B may be set independently to any of the allowable combinations of source and coupling. When EXT, external input, is selected as the trigger source, A takes its input from the EXTERNAL TRIGGER A BNC socket, and B takes its input from the EXTERNAL TRIGGER B BNC socket.

A/B TRIGGER (8) This button controls which channel's status is viewed on the LED display. The light above the button shows which channel is currently being displayed. When selected in this way the source and coupling buttons will change the setup of the channel.

Source (9) Steps through the available options of trigger source. After line has been selected, a further press of the button returns the selection to CH1.

The options are:

4071 – CH1, CH2, EXT and LINE.
4072 – CH1, CH2, EXT and LINE.
4074 – CH1, CH3, EXT and LINE.

Coupling (10) Steps through the available options of trigger coupling. These are AC, ACHP(AC High Pass), ACLP(AC Low Pass),DC, & DCLP(DC Low Pass). After DCLP has been selected, a further press of the button returns the selection to AC. All the couplings can be used with the internal and EXT sources. For LINE, the input coupling is not selectable.

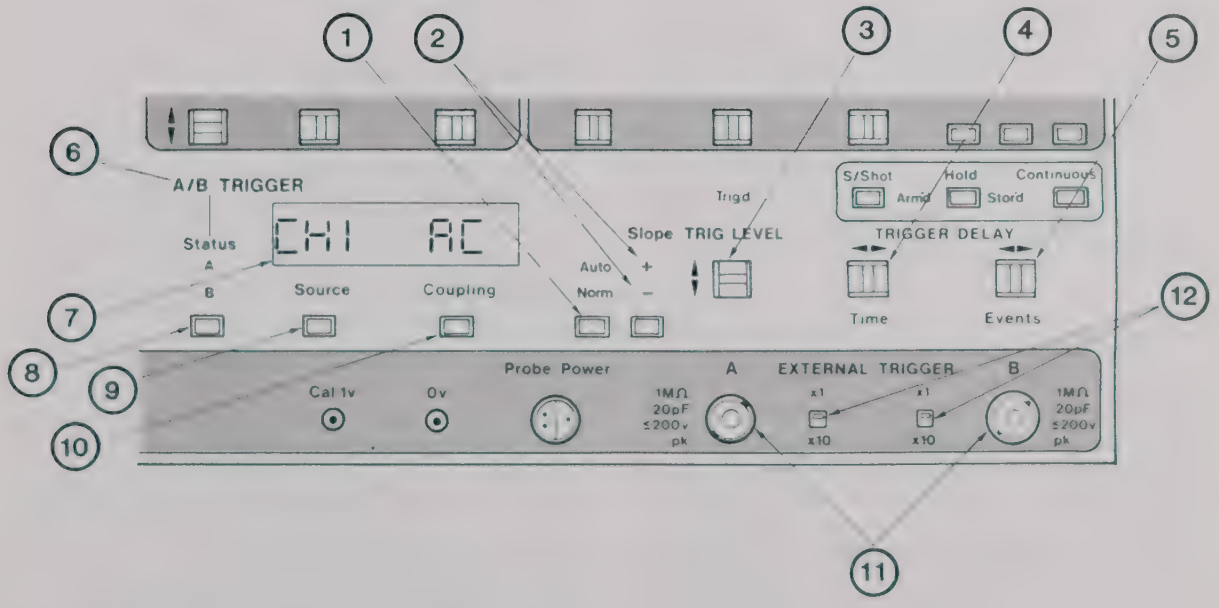


Figure 1.4.1 Trigger Controls (4071, 4072 and 4074)

Table 1.4.1 Choices of Source and Coupling

4071 & 4072:–

Source	Coupling
CH1, CH2, EXT	AC, ACHP, ACLP, DC, DCLP, TVLN, TVFR
LINE	None

4074:–

Source	Coupling
CH1, CH3, EXT	AC, ACHP, ACLP, DC, DCLP, TVLN, TVFR
LINE	None

Table 1.4.2 Useful Frequency Ranges of Coupling Types

Coupling	Input Frequencies
AC	10Hz to 100MHz
ACHP	15kHz to 100MHz
ACLP	10Hz to 15kHz
DC	DC(0Hz) to 100MHz
DCLP	DC(0Hz) to 15kHz
TVFR	Composite video: PAL, NTSC or SECAM
TVLN	Composite video: PAL, NTSC or SECAM

TV Sync Separator

The 4070 contains an integral TV Sync Separator. This provides two of the couplings, namely TVLN (TV line sync) and TVFR (TV frame sync). These are not directly selectable from the front panel, but are selected via the TV and Special Functions menu (see Section 2.9).

The TV sync separator giving TV frame and TV line operates the A trigger channel. If TV line is selected on the B trigger channel then the B trigger signal is taken from the A channel as its source.

Trigger Level (3)

The trigger level is set by the **TRIG LEVEL** paddle. This has five positions: fast up; slow up; no change; slow down; fast down.

In general, it is not necessarily possible to relate the trigger level to a particular vertical point on the screen trace. To overcome this problem there are two bars, one on the left and one on the right-hand side of the screen. These show the relative position of the trigger level to the screen trace.

NOTE: Care should be taken when using the on-screen trigger level as there will be no relationship between the trace and trigger level unless they both have the same coupling.

Trig'd This lights up when the 4070 is receiving valid A trigger signals at a rate greater than one every 30ms.

Trigger Slope (2)

A trigger is generated when the selected source signal passes through the chosen trigger level. This transition may be either on a rising or a falling edge. The rising edge is considered to be the positive slope and the falling edge a negative slope.

+/– This button selects positive or negative slope triggers. The current selection is indicated by the light above the button. If negative slopes are selected then a single press will select positive slopes and a further press reverts to the negative slopes.

Auto Trigger (1)

There are two modes in which the trigger system can operate: Auto and Normal. In Normal mode, trace captures can only occur when a valid trigger input has been received. When Auto is selected, if no valid trigger has been received for some time the instrument will generate its own trigger and initiate a capture. This ensures that the screen is constantly updated irrespective of the input signal. However, if valid triggers are received at a rate as low as 30Hz the instrument will start all captures with these and not generate its own triggers.

Auto/Norm This button selects which trigger mode the instrument is operating in. The current mode is indicated by the light above the button. If Auto is selected then one push will select Normal and a further push will re-select Auto.

Note: *Auto is not possible for B trigger.*

External Trigger Inputs (11)

The 4070 has two external trigger inputs, labelled EXTERNAL TRIGGER A and EXTERNAL TRIGGER B.

EXTERNAL A This can only be used as a trigger source for the A trigger channel, except when TVFR is selected for A and TVLN for B. In this case, the B trigger source is as the A trigger input.

EXTERNAL B This can only be used as a trigger source for the B trigger channel.

The two inputs have switched gain settings controlled from the front panel; they are labelled **x1/x10**

x1 The external trigger signal is coupled directly into the trigger ciruitry.

x10 The external trigger signal is increased by a factor of 10 before it enters the main trigger circuitry - i.e. a signal only one tenth the size will be required to produce the same effect as on the x1 setting.

Note: *Signals presented at the EXTERNAL TRIGGER inputs should not be more than +/–200V peak. Larger signals could cause damage to the sensitive internal circuitry.*

Trigger Delay

This option allows the user to set two types of delay: delay by time and delay by events. The initiation of a capture will not then take place until the delay conditions, as described below, have been met. The two types of delay are completely independent and it is possible to combine the two. A trigger event as discussed below is a valid trigger as set by the **Source, Coupling, TRIG LEVEL** and **Slope** controls.

Delay by Time (4)

This is set by the **Time** TRIGGER DELAY paddle. This has five settings: decrease time fast, decrease time slow, no change, increase time slow and increase time fast. The delay time step size is dependent on the chosen timebase setting.

Time A gentle push to the left decreases the time delay; a firmer push causes the delay to decrease at a faster rate. A gentle push to the right increases the time delay; a firmer press increases it at a faster rate. If the delay changes to zero, there will be a pause before the change continues.

If the time delay is zero, the trigger point will be at the left-hand edge of the screen. When the delay increases from zero, the display shows events after the trigger point; i.e. the trigger point moves to the left and disappears from the screen altogether. The maximum delay is dependent upon setting.

Timebase Range	Maximum Delay
20s/div to 0.1ms/div	99.9s
50μs/div to 50ns/div	0.99s
20ns	0.4s

The current trigger delay setting is shown in the screen text, e.g.

TBA = 100μs Trig Dly = 300.0μs

The A timebase is set to 100 microseconds per division and there is a delay of 300 microseconds from the trigger point to the start of acquisition, i.e. 3 screen divisions.

When the time delay is decreased from zero, the display shows events leading up to the trigger point: i.e. the trigger point moves to the right and pre-trigger events are captured. The maximum amount of pre-trigger or negative delay time that can be captured is 98%. When this is reached, the trigger point is almost on the right-hand edge of the screen. As the pre-trigger passes through zero or 50%, there will be a pause before the change continues.

Negative delay time is displayed on the screen as a percentage of pre-trigger, e.g.

TBA = 50μs Pre Trig = 30.2%

The A timebase is set to 50 microseconds per division and there is -150.5 microseconds delay. In other words, the trigger point is just over three divisions from the left-hand side of the screen.

Delay by Events (5)

NOTE: This function is available when either A divided by N or B delayed by N is selected from the trigger menu (see section 23.

This option allows the user to control the number of trigger events to be detected before a trace is to be acquired. The delay is set by the Events TRIGGER DELAY paddle. This too has five settings: fast decrease; slow decrease; no change; slow increase and fast increase.

Events A gentle push to the left decreases the number of events, a firmer push decreases the number of events at a faster rate. A gentle push to the right increases the number of events, a firmer push increases the number more quickly.

The number of events currently selected is shown on the screen; e.g.

TBA = 100μs Events = 3

The A timebase is set to 100 microseconds per division and the displayed trace was captured after three valid trigger events were detected.

The minimum number of events delay is zero, whereby the trace will be captured following the first trigger event. The maximum number of events by which capture can be delayed is 999999 (see Section 2.3).

Note that A ÷ N and B delayed by N cannot be selected together.

1.5 BASIC CAPTURE FACILITIES

The basic capture facilities on the 4070 allow the user to freeze the trace on the display. There are two ways to do this: a single-shot capture whereby a full screen is acquired then frozen, or by pressing a **Hold** button. Using a **Hold** button freezes the display the moment it is pressed; this can cause a discontinuity in the trace as the displayed waveform may contain data from more than one capture.

S/Shot (5) This button arms the instrument for a single-shot capture. The Arm'd light will be illuminated to show that the button has been pressed.

Arm'd (4) This light illuminates after the **S/Shot** button has been pressed; it will stay lit until either a valid trigger has been received or until the **Continuous** button is pressed.

Stor'd (3) This light illuminates on completion of a single-shot acquisition. This is after the instrument has been Arm'd, triggered and a trace acquired. The light will stay illuminated until the instrument is re-armed or **Continuous** is pressed.

Continuous (2) This button puts the 4070 in continuous capture mode (i.e. its default state). The instrument will automatically re-arm itself after each capture is completed; this enables the displayed traces to be updated as frequently as possible.

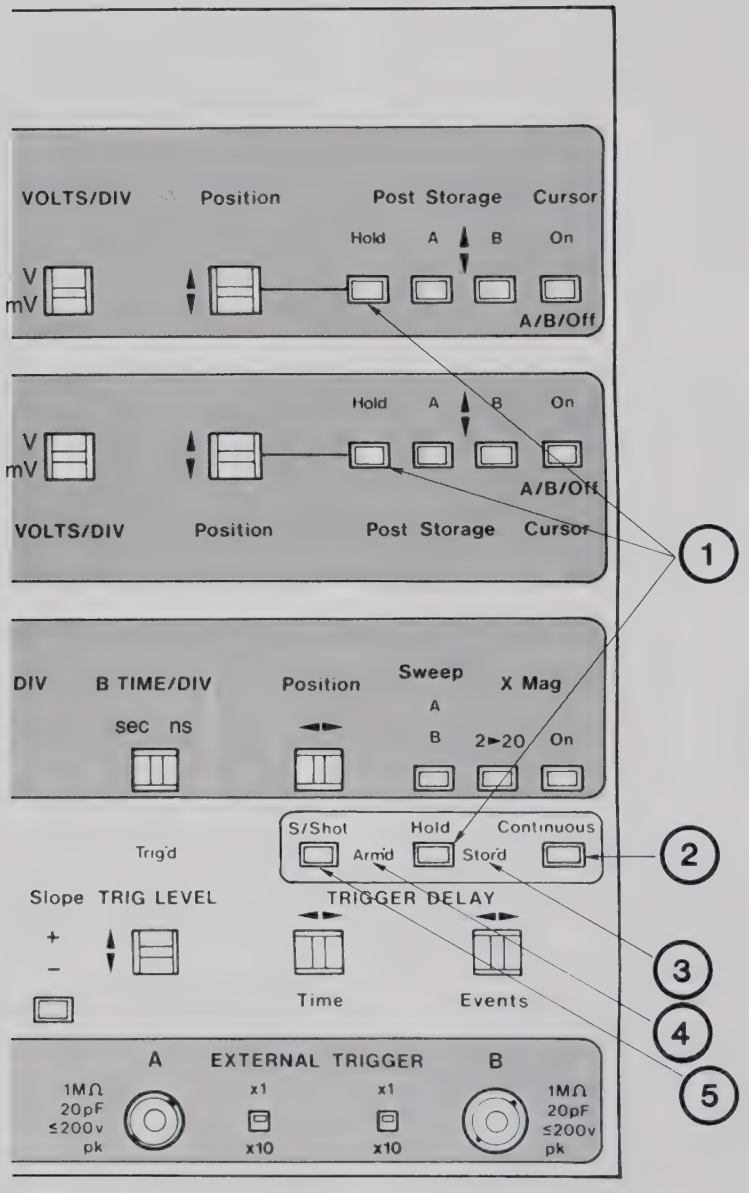


Figure 1.5.1 The Capture Controls (4071/4072 is shown, 4074 is similar)

On the 4070 there are three buttons labelled **'Hold'.** One is located in a group including buttons **S/Shot** and **Continuous:**

Hold (1) between **S/Shot** and **Continuous** freezes the displayed traces immediately irrespective of the stage any ongoing acquisition may have reached. The **Stor'd** light will be illuminated. To release hold simply press either **S/Shot** or **Continuous.**

The other two or four **'Hold'** buttons are associated with the vertical channels; they can be found next to the **Position** paddles. (See Section 1.2).

Hold These buttons freeze the traces of the selected channel only. The Hold light will be illuminated. To release the channel hold simply press the channel **Hold** button again. (See also Sections 1.2 and 1.3).

1.6 CURSOR MEASUREMENTS

The 4070 allows you to take direct measurements from the screen display automatically, using inbuilt cursors. These are movable reference lines which the oscilloscope can display. It takes the measurements between these lines.

Cursor Selection (1)

The cursors for each channel are switched on or off using the **Cursor** button for the respective channel. If the cursors are on, this will be indicated by a light above the button. If X magnification (see Section 1.3) is in use, the cursors may not be visible on the screen, but this is easily remedied using the paddles described below. The cursors can be used on either the A or B traces, selected by successive presses of the button, assuming both traces are active.

Cursor One press of this button brings the cursors on the A timebase trace. Another press moves them to the B timebase trace. A third press of the button switches the cursors off. If only one timebase is displayed, the cursors will be called up onto that trace; a further press of the button will de-select the cursors.

The Cursors

Once activated by a press of the **Cursor** button, three cursors will appear, as indicated in Figure 1.6.2. The large dashed vertical line is the 'time datum' cursor and the short vertical line is the 'minor' cursor. The dashed horizontal line is known as the 'voltage datum' cursor. Note that if the cursors are already selected for one channel, selection of cursors for the other channel will automatically swap them over to the new channel. Movement of the cursors is achieved using the **DATUM** and **CURSOR** paddles.

Movement (2)

The three cursor movement paddles are each five-position switches. The left-hand **DATUM** paddle moves the voltage datum cursor vertically, and the right-hand **DATUM** paddle moves the 'time datum' cursor horizontally. The **Cursor** paddle moves the minor cursor along the trace - i.e. the minor cursor, when moved horizontally, automatically follows the trace up and down as well.

Making Measurements

Example: Frequency and Peak to Peak Voltage.

In Figure 1.6.2, the time and voltage datum cursors have been positioned using the **DATUM** paddles so that they cross at the trough of the waveform. The minor cursor has been positioned at the peak of the waveform using the **Cursor** paddle. The voltage is given at the bottom of the display in the form 'TR1A: 5.25V'. In other words, the vertical difference between the point where the minor cursor intersects the trace and the voltage datum cursor is 5.25 Volts. The 'TR1A' tells you that the measurement was obtained from channel 1 trace A.

At the bottom right of the screen is the reading '551.0 μs', i.e. the time difference between the minor cursor and the time datum cursor is 551 microseconds. This reading is for half a cycle, so the reading for a full cycle should be 1102 microseconds. The frequency is therefore 1/0.001102 = 907Hz. Greater accuracy could be obtained by moving the minor cursor to the next trough (where the voltage difference is zero) and finding the frequency for a complete cycle. In general, greatest accuracy is obtained by taking measurements where the slope of the waveform is at its steepest, such as at 0 Volts rather than at -2.125V as in this example.

Example: Rise Time

The rise time of a wave is the time it takes to traverse the central 80% of its vertical movement. To measure the rise time of, say, a simple sine wave such as that shown in Figure 1.6.3, you would first of all measure the peak to peak voltage as shown in the previous example. Suppose the result of this measurement is 5.25V. Now you would move the time datum cursor to the right using the right-hand **DATUM** paddle until it is at a point 10% of the way up the waveform. Also, use the left-hand **DATUM** paddle to move the voltage datum cursor up so that it intersects the time datum cursor at the point where it crosses the trace. This would be where the vertical difference between the voltage datum cursor and the minor cursor was 5.25-0.525=4.725V. You would then move the **CURSOR** paddle so that the vertical difference reduces to 4.725-0.525=4.2V. The reading in the lower right-hand corner of the screen would then be the rise time.

1.7 INPUT/OUTPUT

The 4070 is equipped with RS423 and GPIB(IEEE488) interfaces, (optional) allowing communication with a host computer. In addition, there is also a keypad option and a Miscellaneous I/O connector, which among other things is used for the analog plot outputs.

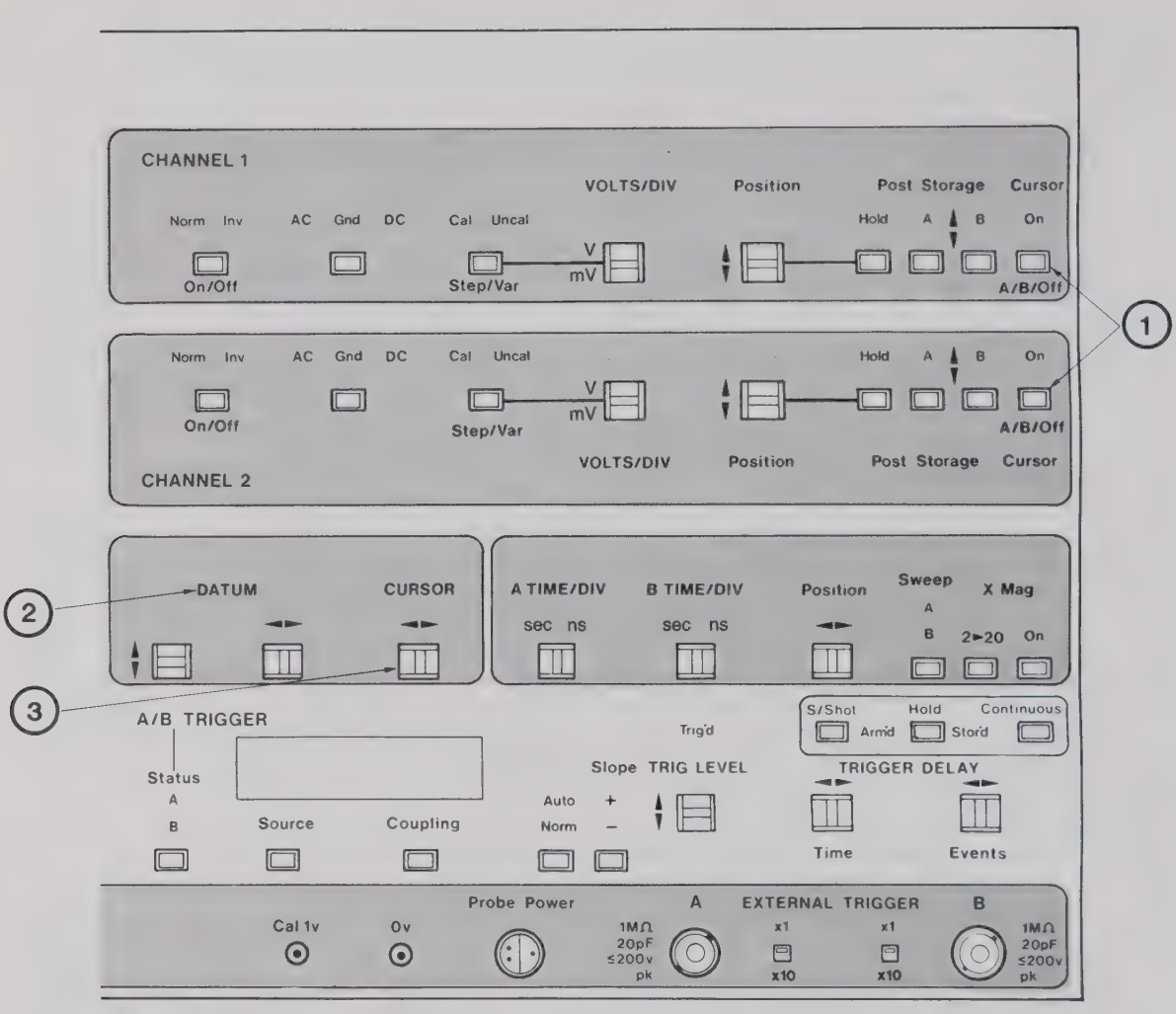


Figure 1.6.1 The Cursor Controls (4071/4072 is shown – 4074 is similar)

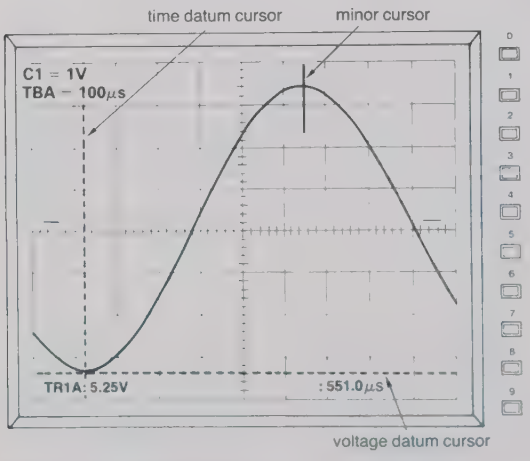


Figure 1.6.2 The Cursors

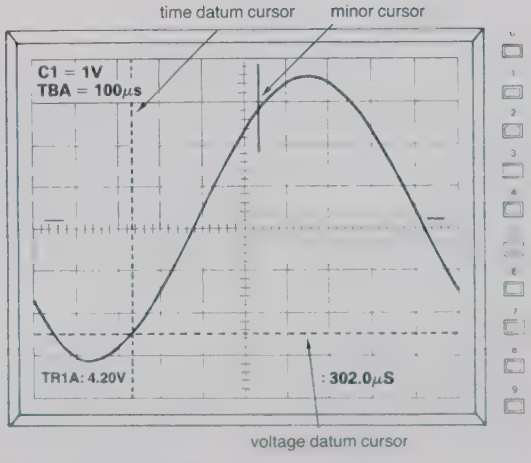


Figure 1.6.3 Rise Time

Waveform Processor

Waveform processors are optional extras. They provide a variety of waveform processing functions such as automatic measurement of risetime, overshoot, frequency, period, and a number of filter and summation functions. Operation information on the current waveform processors available from Gould is available in section (6).

Note: Only a Gould keypad should be fitted to the waveform processor socket. Incorrect connection could damage the internal circuitry.

Miscellaneous Input/Output

This connector is fitted to the rear panel and allows connection to the analogue plot outputs.

The connections are as below.

Table 1.7.1 The Miscellaneous Input/Output Connector.

Pin No.	Name	Description
1	Plot X out	Plot X ramp
2	Y2 Plot out	Y2 output channel
3	not used	
4	PL2	Pen Lift 2
5	0VA	0V analogue
6	EXT PC	External Plot Clock
7	0VL	0V Logic
8	not used	
9	Plot Y out	Y1 output channel
10	not used	
11	PL1	Pen Lift 1
12	0VA	0V analogue
13	+5V	+5V, 100mA max.
14	0VL	0V Logic
15	0VL	0V Logic

Note: *The +5V output on this socket is for test purposes only. If it is used for any reason then the total current must not exceed 100mA.*

Plotting

There are five methods of plotting captured traces from the 4070. These are: internal plotter; RS423; GPIB; single-channel analogue; and dual-channel analogue. All five types are initiated by pressing the **Plot** button. Normally, the 4070 will default to plotting with the internal plotter if fitted. To change to any other type, See Section 2.7. Once another type has been selected this will be the default setting on power-up.

Plot Pressing this button causes the chosen plotter to make a copy of the screen display.

Abort If Abort is pressed while a plot is in progress then the plot is terminated. The present character/line being drawn will be completed and then normal 'scope operation will be resumed.

Note: *It is possible for there to be a slight discrepancy between the position of the plotted trace with respect to the graticule (screen grid) and that of the displayed trace. This is due to the effects of time and temperature on the tube and its display driving circuits. These can cause small offsets to occur on the display, but will have no effect on the graticule, which is part of the display tube glassware.*

The Internal Plotter (option)

The internal plotter of the 4070 enables the user to take copies of the screen display. The plot output includes the graticule (screen grid), a border, all displayed traces and some alphanumerics.

The plotter has four pens: black, blue, green and red. The grid, border and on-screen alphanumerics are plotted in one colour. Each of the four traces has a separate colour of its own, and at the end of each trace an identifier line and label is drawn to distinguish it, see Figure 1.7.1. If the graticule is plotted, traces 1 and 4 use the same colour.

To load paper or install pens see below.

In addition to its normal function, the **Abort** button will also feed enough paper to enable easy removal of the partially plotted picture.

Paper Loading

Please use only Gould paper (Part No: – 04101165 for a pack of 8 rolls).

When loading the internal plotter please follow these steps:

1. With scissors, cut the end of the paper square.
2. Open the printer cover by depressing the catch and lifting the cover until it is fully open.
3. Remove the cardboard roll from the shaft (if the plotter has been used previously).
4. Insert the end of the paper into the slot in the bottom of the plotter.
5. Insert the shaft into the roll and place the roll of paper into paper compartment.

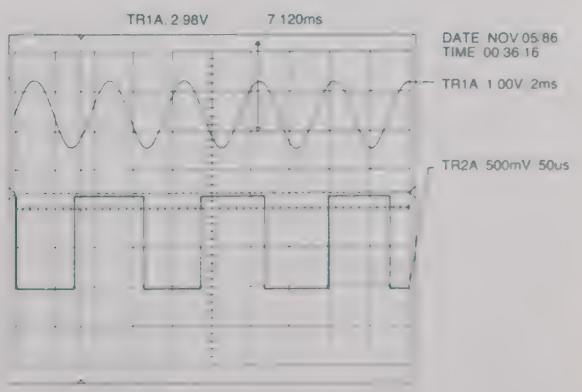


Figure 1.7.1 Example of Plot Output.

6. Press the paper feed button (blue) to get the paper through the slot in the top cover.
7. Close the printer cover – the catch is self-locking.

Pen Installation/Removal

Please use only Gould pens (Part No: – 04101175 for a pack of 1 of each color).

The normal pen sequence is:–

Pen No.	Color
1	Black
2	Blue
3	Green
4	Red

Each pen holder is color coded for this sequence.

To remove a pen, please follow these steps:

1. Ensure that the 4070 is switched on.
2. Open the printer cover by pressing the catch and lifting the cover until it is fully open.
3. Select the PLOT Menu from the Master menu.
4. Press the chart advance button to move the pen carriage to the left side.
5. Press Pen Change to move the carriage to the right side.
6. On the right side there is a wire about 12mm (0.5 in) long pointing to the left. Above it, and to the right, there is a small white lever – the Pen ejection lever. Gently press down on this lever and the wire will go up. When a pen is in the holder, this will "pop" the Pen out.
7. To instal a pen insert the tip of the pen into the Pen Wheel Guide hole (remember to match the color on the pen with the color on the holder). Gently "snap" the other end of the Pen into place.
8. To change a different pen press chart advance to move the pen carriage to the left side and press Menu button 8 – "Change Plotter Pen". Repeat steps 5 to 8 until finished.
9. Close the printer cover.

GPIB/RS423 Plots (only if interface fitted)

The 4070 can operate in stand-alone mode to drive a digital GPIB or RS423 plotter. The output will be of the same form as the internal plotter, shown in Figure 1.7.1. The choice of colours is dependent on the pens used and the number available.Some plotters are able to detect missing pens: in these cases another pen will be selected.

Data output from the 4070 to the plotter is in HPGL, Hewlett-Packard Graphics Language.

Single-Channel Analog Plot

Single-channel plot is for use with single-pen plotters. This uses the analog outputs from the Miscellaneous I/O connector. Pen lift is available from this connector, PL1 and PL2, these two outputs being connected together to lower the pen.

The signal 'Y plot out' has a range of −400mV to +400mV. 'X Plot Out' has a range from 0V to +1V. When no plots are in progress the outputs will be 0V. The format of the output will be limited to traces only: there will be no grid, border or alphanumerics. Only displayed traces will be plotted – see 4072/4074 Plotting Order (below).

Dual-Channel Analog Plot

Dual-channel plot is for use with plotters having two or more pens. It uses the analog outputs from the Miscellaneous I/O connector. The format is the same as single channel plot, i.e. traces only. A second Y output, 'Y2 plot out', is also on the Misc. I/O connector.

The order in which the traces are plotted can become fairly complex.

4071 and 4072 Plotting Order

When plotting a Y-T display in single pen analog mode, the eight traces will be output in the following sequence:–

TRACE1A, TRACE3A, TRACE2A, TRACE4A, TRACE1B, TRACE3B, TRACE 2B, TRACE 4B.

Note: the trace plot will be available at both the Y1 and Y2 outputs.

When plotting an X-Y display in single pen analog mode, the sequence from Y1 will be the same as for YT mode, but the channel supplying the X signal will be available at both the X and Y2 outputs.

An X-Y display in dual pen analog mode behaves in the same way as the single plot analog plot.

When plotting a Y-T display in dual pen analog mode, there are three different sequences:–

1. **A traces only**
   a) single trace displayed, output to Y1 and Y2
   b) two traces displayed, "earlier" trace (in the single pen eight trace sequence above) to Y1, other trace to Y2, e.g. for
      TRACE2A and TRACE3A
      Y1 = TRACE3A, Y2 = TRACE2A
   c) three traces displayed. The traces are paired as TRACE1A with TRACE3A and TRACE2A with TRACE4A; if a trace's pair is not present it is paired with itself. The "earlier" trace of the pair will be directed to Y1, e.g. TRACE1A, TRACE2A and TRACE4A will first output
      Y1 = TRACE1A, Y2 = TRACE2A
      and then output
      Y1 = TRACE4A, Y2 = TRACE4A
   d) four traces displayed. The traces are output as
      Y1 = TRACE1A, Y2 = TRACE3A
      followed by
      Y1 = TRACE2A, Y2 = TRACE4A
2. **B traces only**
   For B traces only the output sequence is the same as that for case 1., but using the B traces.

3. **Mixed A and B traces**
Each A trace is paired with its equivalent B trace; if an equivalent trace is not present, the trace is paired with itself, e.g. TRACE1A, TRACE3A, TRACE3B will generate the output sequence.
Y1 = TRACE1A, Y2 = TRACE1A
Y1 = TRACE3A, Y2 = TRACE3B
Y1 = TRACE2B, Y2 = TRACE2B.

4074 Plotting Order

When plotting a Y-T display in single pen analog mode, the eight traces will be output in the following sequence:–

TRACE1A, TRACE2A, TRACE3A, TRACE4A, TRACE1B, TRACE2B, TRACE 3B, TRACE 4B.

Note: the output trace plot will be available at both the Y1 and Y2 outputs.

When plotting an X-Y display in single pen analog mode, the sequence from Y1 will be the same as for Y-T mode, but the channel supplying the X signal will be available at both the X and Y2 outputs.

An X-Y display in dual pen analog mode behaves in the same way as the single analog plot.

When plotting a Y-T display in dual pen analog mode, there are three different sequences:–

1. **A traces only**
a) single trace displayed, output to Y1 and Y2
b) two traces displayed, "earlier" trace to Y1, other trace to Y2, e.g. for
TRACE2A and TRACE3A,
Y1 = TRACE2A, Y2 = TRACE3A
c) three traces displayed. The traces are paired as TRACE1A with TRACE3A and TRACE2A with TRACE4A; if a trace's pair is not present it is paired with itself. The "earlier" trace of the pair will be directed to Y1, e.g. TRACE1A, TRACE2A and TRACE4A will first output
Y1 = TRACE1A, Y2 = TRACE1A
and then output
Y1 = TRACE2A, Y2 = TRACE4A
d) four traces displayed. The traces are output as
Y1 = TRACE1A, Y2 = TRACE3A
followed by
Y1 = TRACE2A, Y2 = TRACE4A

2. **B traces only**
For B traces only the output sequence is the same as that for case 1., but using the B traces.

3. **Mixed A and B traces**
Each A trace is paired with its equivalent B trace; if an equivalent trace is not present, the trace is paired with itself, e.g. TRACE1A, TRACE3A, TRACE2B, TRACE3B will generate the output sequence.
Y1 = TRACE1A, Y2 = TRACE1A
Y1 = TRACE2B, Y2 = TRACE2B
Y1 = TRACE3A, Y2 = TRACE3B.

RS423

RS423 is an upgrade from RS232. Provided cabling and handshaking are correctly set then there should be no problems interfacing the 4070 RS423 to any RS232 or RS423 equipment.

One difficulty that can be encountered in using RS423/RS232 is the direction of the data and handshake lines. This is usually overcome by making up special cableforms. On the 4070 it has been overcome by having all the lines internally settable.

The instrument is shipped from the factory with the following configuration:

Table 1.7.3 The RS423 connector

Pin No.	Name	Description
1	0VL	0V Logic
2	TX	Transmit Data
3	RX	Receive Data
4	RTS	Request To Send
5	CTS	Clear To Send
6	DSR	Data Set Ready
7	0VL	0V Logic
8	DCD	Data Carrier Detect
9	True	RS423 Logic True
14	True	RS423 Logic True
20	DTR	Data Terminal Ready

To re-set the connection order or to remove the handshaking it is necessary to gain access to the inside of the instrument.

Changing the RS423 Connections

It is recommended that this operation be carried out by suitably qualified personnel.

WARNING: *Once the covers are removed from the instrument dangerous voltages are exposed. In particular, the area around the tube base will have voltages in excess of 2kV, which may be retained for several minutes after power down.*

1. Remove the mains connector.
2. Remove the top cover. Use the correct tools as damage to the screw heads could make the cover very difficult to remove.
3. Carefully examine the contents of the instrument. You will notice there are six cards in a rack (4074=7) to carry out this operation you will need to remove the Input/Output board. This is situated nearest to the display tube.
4. Remove the card retaining bar.
5. The I/O board is situated in the middle of the instrument,nearest to the display tube. It is also identifiable by the cableform entering it towards the rear.

Take note of how the cable enters the board and then remove it by using the pull-tab. This cable is the connector to the GPIB interface.

6. Remove the I/O board taking care not to damage the GPIB cable on the rear of the board.

7. Carefully examine the I/O board. In the bottom left-hand corner you will notice a group of 18 pins with jumpers.

There are six groups of connections, a to f. On each group it is possible to have the jumper on either the up or the down position.

Work out the connections you require at the rear panel, consult the table below and move the jumpers accordingly.

Table 1.7.4 I/O Connections

Group	Position	Description
a	up	Pin 2 is RX
	down	Pin 3 is RX
b	up	Pin 3 is TX
	down	Pin 2 is TX
c	up	Pin 5 is RTS
	down	Pin 4 is RTS
d	up	Pin 4 is CTS
	down	Pin 5 is CTS
e	up	Pin 6 is True
	down	Pin 20 is True
f	up	DCD is True, Pin 8 is True
	down	Pin 8 is DCD

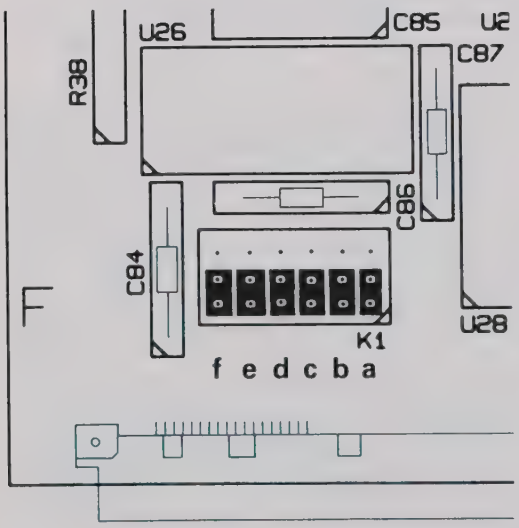


Figure 1.7.2 RS423 Jumpers as Supplied from the Factory.

Replacing the I/O board is the reverse of removal. In doing so take care not to damage the GPIB cable when inserting the board and remember to press the plug fully home in the I/O board.

In addition to the connections it is possible to set the baud rate, the parity, handshake and echo and prompt. These can all be set through the menu described in Section 2.8.

The instrument is supplied with the following set-up: 9600 baud; eight bits; no parity; and two stop bits. Once changed through the menu system the new setting will be the power-on default set-up.

1.8 COMMUNICATION VIA GPIB/RS423

The GPIB and RS423 interfaces are options. Either the GPIB or RS423 communication ports may be used to link the 4070 series instruments with a host computer. Although the two ports are electrically different, the communication format is essentially the same in either case. There are certain differences in the method of terminating a message or data block transmitted, owing to the fact that the parallel GPIB port has a dedicated signal line associated with flagging the end of a data transfer. The difference in this respect are described in 'Blocks' below. Apart from the introductory paragraphs below, the following section is equally applicable both to GPIB and RS423 operation.

GPIB (IEEE-488)

This is a versatile parallel bus interface allowing fast communication between a host computer and up to 30 peripherals. It is based on a controller/talker/listener structure whereby the host computer (usually the controller) commands various peripherals to 'talk' or 'listen' according to the desired path of data flow. An addressing scheme permits each peripheral to be referred to uniquely. Users unfamiliar with GPIB may wish to refer to Appendix 1.

There are three main modes available when using GPIB:

Local The operator has full control of the instrument via the front panel. The 4070 may be interrogated but not manipulated in any way by the host computer.

Remote All of the 4070 GPIB commands can be used when in this mode. The only front panel button still operative is the Abort button, which returns the instrument to local mode.

Local Lock Out This is an extension to remote mode. When the instrument is placed in this state the operator has no control from the front panel.

GPIB and RS423 Command Syntax

The commands of the 4070 are simple and English-like. Where necessary, mnemonics have been used to replace large words or text. To enable the user to send more readable commands, spaces may be inserted freely within the commands. All spaces will be ignored except with the TXT command.

Strings

A string is the smallest complete message that can be sent over the bus.

e.g. "HSA=5E+3"

Commas may be used as separators within a string and semi-colons can be used to separate strings from each other.

e.g. "HSA=5E+3;ST1=1,2,3....."

A string may contain only ASCII characters, except binary blocks (see later). The space, character codes above 127 (decimal) and control codes other than line feed will be ignored.

Numbers

Numbers that appear in commands must conform to certain conditions:

1. the number must contain less than 20 characters;
2. the mantissa must be an integer, i.e. it must not contain a decimal point; unless it is in the form 0.5E-3;
3. the mantissa may contain a sign (+/−); + will be assumed if none is specified;
4. the exponent is optional; if included it must be preceeded by an 'E';
5. the exponent may contain a sign; if omitted + is assumed

Blocks

The buffer of the 4070 is of limited size: when large data transfers are being carried out it is necessary to break them into smaller groups, or blocks. Differences arise here between RS423 and GPIB working. RS423 accepts ‹cr› and ‹lf› as terminators in different combinations. The GPIB port does the same, but in addition, the dedicated EOI (End Or Identify) bus line may be used. This line can be asserted with the final character of a transfer to signify end of transmission (as opposed to end of block). In the 4070 this is optional, the *command* EOI being used to enable or disable the use of this line. Block termination codes available for both ports are as follows (reference to EOI clearly relate only to GPIB working):

As separator between blocks:

1. ‹cr› ‹lf›
2. ‹lf› without EOI asserted.

As final block terminator:

3. ‹cr› ‹lf›, EOI asserted with ‹lf›.
4. ‹lf› with EOI (if EOI = ON has been set).
5. ‹lf› without EOI (if EOI = OFF has been set).

Records

A record is a group of one or more command strings. The strings will be separated by semi-colons within the record. Records are separated in the same way as blocks and therefore the final record must be terminated by methods 3, 4 or 5 above.

The simplest form of record has a single string and is terminated by a ‹lf› with EOI.

e.g. "HSA=5E−3 ‹lf›" EOI asserted with ‹lf›

If a record (or a block) exceeds 82 characters, the command interpreter will process the record as far as it can.

Each complete command string within the 82 character group will be executed, though an error message may be returned if part of a further command string occurs at the end of the buffer. This command will however be correctly executed once it has been received complete.

Command Types

There are three types of command:

Interrogative This is a request for information about instrument status or for the contents of a memory to be transmitted.

Assertive These commands request a change in one of the settings or memory of the instrument. They are only valid when in Remote or Local Lock Out mode. They have the form 'parameter=setting'.

Direct Action Assertive These commands have a direct action rather than changing a setting. They are only valid in Remote and Local Lock Out modes.

Service Requests

Service requests are generated by the 4070 to inform the bus controller that some event or problem has occurred. These have no effect upon the instrument and may be ignored. In response to a serial poll or the **SRQV** command the 4070 will supply a number. This has the meaning given in Table 1.8.1.

Table 1.8.1 Service Requests

SRQ No.	Meaning
0	Ok
74	Completed
81	ETS Acquiring
96	Invalid command
98	SRQ stack overflow
99	Command buffer overflow
100	Selection failure
101	Not allowed when Local
102	Syntax error (parameter field)
103	Number out of range
104	Length error (bulk transmissions)
105	Checksum error

Sending and Receiving Stores

There are a few points to note when transferring data from the display trace stores and the reference memory stores. The data may exceed the host computers' buffer size, and may also require a considerable amount of time to transfer (particularly using RS423 at a low baud rate).

The data stream length may be reduced by breaking the data into blocks (though this is not permissible with binary transfers – see later), separated and terminated as described above. Data points are separated by commas. Note that when mass data is sent to the instrument, the size of the block is unimportant and the value of BLL (see command list) need not correspond with it.

Careful choice of numeric base (NB) can reduce transfer time:

Decimal – for simple entry such as to BASIC machines.

Binary – for maximum speed (GPIB only).

Octal/Hexadecimal – faster than decimal and simpler to handle than binary.

When mass data is sent to the 4070, the numeric base is deduced from the header (see later) and need not correspond to the current setting of NB.

If EOI is sent with any character, the instrument will interpret this as meaning the transfer is terminated (unless the command EOI=OFF has been received).

The format of the transmitted data is the same as that of the received data; thus the store can be read, saved and returned at some later date.

Mass Data Format

Mass data transfers have three parts:

1. A header which is specific to the command, e.g. 'TRC1A='.
2. A numeric base specifier:
   #B - Binary
   #O - Octal
   #H - Hexadecimal
   None required - Decimal
3. The data points themselves.

Binary Data Transfers

Sending data in this format is the quickest method: only 1022 bytes are required. In this base the data is not blocked. This mode is not available via RS423 interface.
The format is:

'TRC1A=#BNNdddddd..... dddddCC‹cr›‹lf›'

Where:
#B is the binary, numeric base identifier;

NN is a two-byte byte count of the following data where the checksum is transmitted high byte first. For a full store dump the value is 3F2H bytes.

dddd.....dddd are the 1008 8-bit binary data points.

CC is the two byte checksum transmitted high byte first. The checksum is the sum of all the data bytes ignoring the overflows.

If the transmitted value of NN is incorrect, service request 'length error' is sent and the command terminated. If the checksum is incorrect then the 'checksum error' service request is generated but all the data points will have been loaded into the store.

The following example BASIC program builds up a string containing the header, length, data and checksum for a sample waveform, in this case four ramps. Output of the string to the instrument over GPIB or RS423 has not been included as this is dependent upon the computer used.

```
 10 DIM A$(1500)
 20 C=0    !initialise the checksum
 30 A$="TRC1A=#B"
 40 A$=A$&CHR$(3)&CHR$(242)
 50 !append header, identifier and length
 60 FOR I=0 to 1007    !1008 data points
 70 X=I MOD 256    !generate a ramp
 80 A$=A$&CHR$(X)
 90 C=(C+X) MOD 65536    !update the checksum
100 NEXT I
110 A$=A$&CHR$(C DIV 256)    !checksum high byte
120 A$=A$&CHR$(C MOD 256)    !checksum low byte
130 A$=A$&CHR$(13)    !append ‹cr›
140 A$=A$&CHR$(10)    !append ‹lf›
150 !now send the string
```

Decimal Data Transfers

In this format numbers are sent in ASCII decimal with leading zeros suppressed. This results in transmissions of variable length. The format is as follows:

1. The appropriate header is followed by 1008 decimal numbers separated by comma or ‹cr›‹lf›.
2. Numbers are in the range −128 to +127 with zero corresponding to the centre of the screen and −128 the bottom.
3. Leading zeros are suppressed on output but are acceptable on input.
4. Leading '+' is suppressed on output but is acceptable on input. Plus is assumed if no sign is present.
5. Decimal points or exponents are not accepted.
6. ‹cr›‹lf› is output to separate blocks.
7. Data can be separated by either ‹cr›‹lf› or commas. Block length is irrelevant when transmitting data to the instrument.
8. Transmission is terminated when either EOI is received, if selected, or 1008 data bytes have been received, or ‹lf› alone is received.

Octal Data Transfers

Octal numbers are transmitted in ASCII coded Octal, the format is as folows:

1. The header is followed by 1008 three character octal numbers separated by commas or ‹cr›‹lf›.
2. The numbers are unsigned and in the range 000 to 377, with 000 corresponding to the bottom of the screen.
3. Leading zeros are transmitted but suppression is acceptable on the input.
4. Numbers 6 through 8 under the heading 'Decimal Data Transfers' also apply.

Hexadecimal Data Transfers

Hexadecimal numbers are sent in ASCII as two Hex digits. The format is as follows:

1. The header followed by 1008 two character hexadecimal numbers separated by commas or ‹cr›‹lf›.
2. The numbers are unsigned and in the range 00 to FF with 00 corresponding to the bottom of the screen.
3. Leading zeros are transmitted but suppression is acceptable on the input.
4. Numbers 6 through 8 under the heading 'Decimal Data Transfers' also apply.

GPIB/RS423 COMMANDS

Conventions used in this section

‹cr› the carriage return control code.
‹lf› the line feed control control code.
[ ] denotes one of a set of options.
EOI stands for End Or Identify. (GPIB signal line)

Example:

ADD12=[ON] or [OFF]

Meaning: when you are asserting this command there are two options:

ADD12=ON
or
ADD12=OFF

` ` denotes a reply by the instrument to an interrogative command.

number Where used this means a number is taken as the argument of the command.

GPIB/RS423 Command Summary

Key to the Command Summary:

A Assertive
I Interrogative
D Direct Action Assertive

Command	Parameter	Function	Type
ADD12	ON OFF	Add Channels 1 and 2	A,I
ADD34	ON OFF	Add Channels 3 and 4 (4074 only)	A,I
ALL		Machine Status	I
ARM		Arm the Instrument	D
AUTCAL	ENABLE DISABLE FORCE	Enable/Disable auto cal function	A,I
AVRG	number	Averaging	A,I
AUTSET		Auto Setup	D
BL	number	Block Length	A,I
BLL	number	Block Length	A,I
BWLIM	OFF 20	Bandwidth Limit	A,I
CALBAL		Force Amplifier Balance correction	D
CCAL*		Cursor Calculations	I
CH*	ON OFF	Channel Selection	A,I
CSRHP	number	Cursor, Horizontal Position	A,I
CSRTR	1A 1B 2A 2B OFF	Cursor Trace Selection	A,I
CSRVP		Cursor, Vertical Position	I
DATMH	number	Hor. Datum Position	A,I
DATMV	number	Vert. Datum Position	A,I
DISPLAY	TRACE MENU*	Display menu or trace	A,I
EOI	ON OFF	End or Identify	A,I
GLDET	OFF MAX MIN MAXMIN	Glitch Detect	A,I
GRATYP	SOLID BROKEN	Graticle type	A,I
HE	1 2 5 10 20	Horizontal Expansion	A,I

HELLO		Hello Message	I
HELP		Command List	I
HMOD	A	Horizontal Mode	A,I
	B		
	ALTB		
HOLD*	ON	Channel Hold	A,I
	OFF		
HS[A][B]	number	Horizontal Scaling	A,I
INT	DOT	Interpolation	A,I
	DOTJ		
	LIN		
	SINE		
INV*	ON	Channel Invert	A,I
	OFF		
LOCK	ON	Hold all Channels	A,I
	OFF		
MODE	ROLL	Acquisition Mode	A,I
	REFR		
	XY		
	PTR		
MSAV*		Save Machine Setup	
MSTX*	data field	Transmit Machine Setup	A,I
NB	BIN	Number Base	A,I
	OCT		
	HEX		
	DEC		
PBG*	x1	Probe Gain	A,I
	x10		
	x100		
PH−		Phase Shift −ve	D
PH+		Phase Shift +ve	D
PLOT		Start Plot	D
PLRT	0.005	Plot Rate (DIVS/SEC)	A,I
	0.01		
	0.05		
	0.1		
	0.5		
	1		
	5		
	10		
	EXTERNAL		
PLTDST	GPIB	Plot Destination	A,I
	ANSGL		
	ANDL		
	PRNT		
	SRL		
PLTGT	ON	Plot Graticule	A,I
	OFF		
PLTMD	AUTO	Plot Mode	A,I
	SNGL		
PLTR	ON	Plot Traces Only	A,I
	OFF		
RCLMS*		Recall Machine State	D
REFM*	mass transfer	Reference Store Transfer	A,I
	TRC1A		
	TRC1B		
	TRC2A		
	TRC2B		
REL		Release	D

RM*HS	number	Reference Trace Hor. Scaling	A,I
RM*VS	[-][›]number[~]	Reference Trace Vert. Scaling	A,I
RPBG	*	Remote Probe Gain	I
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
RTPL	0.1	Rate of Plot (SEC/DIV)	A,I
	0.2		
	1		
	2		
	10		
	20		
	100		
	200		
	EXTERNAL		
SHFT	number	Horizontal Shift	A,I
SRQV		Service Request Value	I
STAT		Acquisition Status	I
TDELA	number	Trigger A Delay by Time	A,I
TDELB	number	Trigger B Delay by Time	A,I
TEVNT	number	Trigger Delay by Events	A,I
TGAAUT	ON	Auto trigger	A,I
	OFF	mode on or off	
TL[A][B]	number	Trigger Level	A,I
TOF	TOF*	Trace on off status	I
	TOF1A		A,I
	TOF2A		
	TOF3A		
	TOF4A		
	TOF1B		
	TOF2B		
	TOF3B		
	TOF4B		
TRGC[A][B]	DC	Trigger Coupling	A,I
	AC		
	ACLP		
	ACHP		
	DCLP		
	TVL		
	TVF		
TRGMD[A][B]	A	Trigger Mode	A,I
	B		
	ADIVN	A Trig ÷N	
	BGAT_ADELN	B gate A delayed by NxB	
	AGATB	A gated by B	
	BDELN	B delayed by NxB	
	BGAT_ADIVN	B gated by A Trig ÷N	
TRC*A	mass transfer	Display Trace Transfer	A,I
	REFM1		
	REFM2		
	REFM3		
	REFM4		

TRC*B	mass transfer	Display Trace Transfer	A,I
	REFM1		
	REFM2		
	REFM3		
	REFM4		
TRHS[A][B]	number	Hor. Trace Scaling	A,I
TRVS[A][B]	[-][›]number[~]	Vert. Trace Scaling	A,I
TS[A][B]	CH1	Trigger Source	A,I
	CH2		
	EXTA		
	EXTB		
	LINE		
TSL[A][B]	MINUS	Trigger Slope	A,I
	PLUS		
TXT*	"string"	On Screen Text	A,I
VC*	AC	Vertical Coupling	A,I
	DC		
	GND		
VG*	number	Variable Gain	A,I
VP*	number	Vertical Position	A,I
VPS[A][B]	number	Post Storage Shift	A,I
VS*	[-][›]number[~]	Vertical Scaling	A,I
WIND	number,number	Trace Window	A,I

Function: **Add Channels 1 and 2**

Type: Assertive, Interrogative

Syntax: ADD12
ADD12=[ON] or [OFF]

Explanation: This command causes input channels 1 and 2 to be added together before being digitised. The resulting trace is placed in the Channel 1 store.

Examples: ADD12
'ADD12=ON' (4070 response)
ADD12=OFF

See also: Section 2.4

Function: **Add Channels 3 and 3 (4074 only)**

Type: Assertive, Interrogative

Syntax: ADD34
ADD34 = [ON] or [OFF]

Explanation: This command input channels 3 and 4 to be added together before being digitised. The resulting trace is placed in the channel 3 store.

Examples: ADD34
'ADD34 = ON' (4074 response)
ADD34 = OFF

See also: Section 2.4.

Function: **Complete Machine Status**

Type: Interrogative

Syntax: ALL

Explanation: This causes the complete state of the instrument to be output as though the relevant interrogatives had been sent. Its response will be a number of strings each separated by ';', if the block length is non-zero then each block will be separated by ‹cr›‹lf› with EOI, if selected, set on the final ‹lf›.

Example: ALL
'ADD12=ON;.....;WIND=0,1007‹cr›‹lf›'

See also: HELP

Function: **Arm**

Type: Direct Action Assertive

Syntax: ARM

Explanation: This command produces the same effect as pressing the front panel **S/Shot** button.

Service request 74 will be generated when the instrument has been armed. If, for some reason, the trace cannot be captured, service request 100 will be generated.

Notes: *It is not possible to arm the instrument with this command if:*

1. **LOCK** *is on;*
2. *All the traces are in hold;*
3. *The instrument is in* **LOCAL;**
4. *The instrument is in menu mode.*

See also: Section 1.5

Function: **Autocal**

Type: Assertive, Interrogative

Syntax: AUTCAL
AUTCAL = [ENABLE] or [DISABLE] or [FORCE]

Explanation: Autocal performs a regular adjustment cycle on the CCD in the acquisition system and also balances the Y-amplifier. This can be controlled remotely eg. to avoid the function coinciding with a timed measurement process. Note that if the function is removed for extended periods the trace may become noisy particularly on fast timebase speeds.

Function: **Averaging**

Type: Assertive, Interrogative

Syntax: AVRG
AVRG=number

Explanation: It is possible for the 4070 to continuously capture traces and the new trace is added to the old and the new trace is weighted by the factor. When AVRG is set to 1 then the feature is disabled. The allowable options are: OFF, 2, 4, 8, 16, 32, 64, 128 and 256.

Examples: AVRG
'AVRG=4' (4070 response)
AVRG=128

Note: *If this feature is used with Max-Min then the results can be unpredictable. Averaging cannot be performed in roll mode.*

See also: Section 2.4

Function: **Auto Setup**

Type: Direct Action Assertive

Syntax: AUTSET

Explanation: This command produces the same effect as pressing the **Auto Setup** button on the front panel.

See also: Section 1.1

Function: **Block Length**

Type: Assertive, Interrogative

Syntax: BL
BLL
BL=number
BLL=number

Explanation: This command defines the length of the blocks used during bulk transmissions. Its default state is zero, which selects infinite length blocks. Values from 0 to 256 may be used. Apart from zero these specify the maximum number of characters that will be sent before a ‹cr›‹lf›.

Examples: BLL
'BLL=0' (4070 response)
BL=73

Notes: *The number specified is the maximum number of characters that will be sent before ‹cr›‹lf›. If leading zero suppression (and numberic base = decimal) is used each block may be of different length.*

Function: **Bandwidth Limit**

Type: Assertive, Interrogative

Syntax: BWLIM
BWLIM=[OFF] or [20]

Explanation: This command allows the bandwidth limit of the 4070 to be set or interrogated as **OFF** or **20MHz.**

Examples: BWLIM
'BWLIM=OFF' (4070 response)
BWLIM=20

See also: Section 2.4

Function: **Force Amplifier Balance Correction**

Type: Direct Action Assertive

Syntax: CALBAL

Explanation: When this command is received, the 4070 is forced to carry out a calibration of the Y amplifier offsets. When the calibration is complete, a SRQV=74 is returned.

Example: CALBAL

See also: Section 2.9

Function: Cursor Calculations

Type: Interrogative

Syntax: CCAL

Explanation: This command returns the trace and voltage and time differences corresponding to the positions of the cursor and datums. If a keypad is installed then the current keypad calculation results are returned instead.

Example: CCAL
'CCAL=TRIA:7.261:38.25' (4070 response)

Note: *If the cursors are not selected when this command is issued service request 100 will be generated.*

See also: Section 1.6

Function: **Channel Selection**

Type: Assertive, Interrogative

Syntax: CH1
CH2
CH3 } 4074 only
CH4 }
CH*

CH1=[ON] or [OFF]
CH2=[ON] or [OFF]
CH3=[ON] or [OFF]
CH4=[ON] or [OFF]
CH*=[ON] or [OFF]

Explanation: Switches on or off any of the vertical channels. CH* returns the status of the channels or switches them on or off.

Examples: CH1=ON
CH2
'CH2=OFF' (4070 response)

See also: Section 1.2

Function: **Cursor, Horizontal Position**

Type: Assertive, Interrogative

Syntax: CSRHP
CSRHP=number

Explanation: In its assertive form this command moves the cursor to the specified horizontal position on the screen. The range is 0 to +10.07, zero being the left-hand edge of the screen and 10.07 being the right-hand edge.

Examples: CSRHP=5

CSRHP
'CSRHP=3.7' (4070 response)

See also: DATMH, DATMV, CSRVP, Section 1.6

Function: **Cursor Trace Selection**

Type: Assertive, Interrogative

Syntax: CSRTR
CSRTR=[1A], [1B], [2A], [2B], [3A], [3B], [4A], [4B], or [OFF]

Explanation: This command moves the cursors to the specified trace, or indicates on which trace they will appear when they are selected. If OFF is sent then the cursors will be switched off.

Examples: CSRTR=1A

CSRTR
'CSRTR=2A' (4070 response)

Note: *Cursors can only be moved to a trace that is currently being displayed.*

See also: Section 1.6

Function: **Cursor, Vertical Position**

Type: Interrogative

Syntax: CSRVP

Explanation: The vertical position of the cursor is determined by its position on the selected trace. This has a range of +/−4.48 screen divisions, zero being the centre of the screen and +4 the top of the grid.

Examples: CSRVP
'CSRVP=4.1' (4070 response)

See also: DATMH, DATMV, CSRHP, Section 1.6

Function: **Time Datum Position**

Type: Assertive, Interrogative

Syntax: DATMH
DATMH=number

Explanation: In its assertive form this command moves the time datum cursor to the specified position on the screen. The range is 0 to +10.07, zero being the left-hand edge of the screen and 10.07 being the right-hand edge.

Examples: DATMH=9.4

DATMH
'DATMH=3.7' (4070 response)

See also: DATMV, CSRHP, CSRVP, Section 1.6

Function: **Voltage Datum Position**

Type: Assertive, Interrogative

Syntax: DATMV
DATMV=number

Explanation: In its assertive form this command moves the voltage datum cursor to the specified position on the screen. The range is +/−4.48, zero being the centre of the screen and +4 being the top of the grid.

Examples: DATMV =0.5

DATMV
'DATMV=1.35' (4070 response)

See also: DATMH, CSRHP, CSRVP, Section 1.6

Function: **Display Menus or Traces**

Type: Assertive, Interrogative

Syntax: DISPLAY
DISPLAY=[TRACE] or [MENU][number]

Explanation: This command controls whether traces or menus are displayed. If menus are chosen then this is accompanied by the menu number:

MENU0 - Master Menu
MENU1 - Status Menu
MENU2 - Trigger Menu
MENU3 - Display Menu
MENU4 - Help Menu
MENU5 - Save and Recall Setup Menu
MENU6 - Plot Menu
MENU7 - I/O Interfaces Menu
MENU8 - TV and Special Functions Menu

The trace display consists of those traces selected by CH* command.

Examples: DISPLAY=MENU4

DISPLAY
'DISPLAY=TRACE' (4070 response)

See also: CH*, Section 2.1

Function: **End or Identify**

Type: Assertive, Interrogative

Syntax: EOI
EOI=[ON] or [OFF]

Explanation: This command affects only the GPIB interface. When EOI is asserted this indicates the end of the present transmission. If EOI=OFF then EOI will be ignored if asserted. EOI = ON is the default at power on.
(See 'Blocks' Section 1.8).

Examples: EOI=OFF

EOI
'EOI=OFF' (4070 response)

Function: **Glitch Detect**

Type: Assertive, Interrogative

Syntax: GLDET
GLDET=[OFF] or [MAX] or [MIN]
or (MAXMIN]

Explanation: This command allows the glitch detector of the 4070 to be configured as if from the menu.

Examples: GLDET
'GLDET=OFF' (4070 response)
GLDET=MAXMIN

See also: Section 2.4.

Function: **Alter Graticule Type**

Type: Assertive, Interrogative

Syntax: GRATYP
GRATYP=[SOLID]
GRATYP=[BROKEN]

Explanation: This command allows the graticule to be plotted either SOLID or BROKEN.

Example: GRATYP=[SOLID]
GRATYP
'GRATYP=[SOLID]' (4070 response)

Function: **Horizontal Expansion**

Type: Assertive, Interrogative

Syntax: HE
HE=[1], [2], [5], [10] or [20]

Explanation: This command allows the present X magnification to be interrogated or a new value set. This works in the same way as the front panel buttons X Mag ON and X Mag 2▶20, although this one command can perform both

functions. There are five possible options, x1 or OFF, x2, x5, x10 and x20.

Examples HE=5
HE
'HE=1' (4070 response)

Notes: *In the same way as the front panel buttons, HE expands the trace around the present centre of the screen.*

See also: HSA, HSB, INT, Section 1.3

Function: **Hello Message**

Type: Interrogative

Syntax: HELLO

Explanation: This command returns the message 'Gould, 4071, Software issue no.', 'Gould, 4072, Software issue no.' or 'Gould, 4074, Software issue no.'

Function: **Command List**

Type: Interrogative

Syntax: HELP

Explanation: When this command is issued the 4070 responds with a list of all the allowable command names.

See also: ALL

Function: **Horizontal Mode**

Type: Assertive, Interrogative

Syntax: HMOD
HMOD=[A], [B] or [ALTB]

Explanation: This command sets or interrogates the horizontal mode of the instrument. There are three modes:

A	A timebase traces only;
B	B timebase traces only;
AALTB	A ALTernate B. Dual timebase mode: the 4070 alternately captures traces on the A then the B timebase ranges. Timebase A captures traces into stores 1A and 2A, timebase B captures into stores 1B and 2B.

Examples: HMOD=ALTB
HMOD
'HMOD=B' (4070 response)

See also: Section 1.3

Function: **Channel Hold**

Type: Assertive, Interrogative

Syntax: HOLD1
HOLD2
HOLD3 (4074 only)
HOLD4 (4074 only)
HOLD*
HOLD1=[ON] or [OFF]
HOLD2=[ON] or [OFF]
HOLD3=[ON] or [OFF] (4074 only)
HOLD4=[ON] or [OFF] (4074 only)
HOLD*=[ON] or [OFF]

Explanation: In its assertive form this command can hold or release any of the channels, or all channels simultaneously with HOLD*. This action is the same as the front panel channel hold buttons.

Examples: HOLD*=ON
HOLD1
'HOLD1=OFF' (4070 response)

See also: LOCK, Section 1.5

Function: **Horizontal Scaling**

Type: Assertive, Interrogative

Syntax: HSA
HSA=number
HSB
HSB=number

Explanation: The horizontal scaling, or timebase, can be set with this command. The range is 20ns per division to 20s per division, in 1, 2, 5 steps. HSA sets or reads the A timebase whereas HSB sets and reads the B timebase.

Examples: HSA=5E-3
HSB
'HSB=1E-6' (4070 response)

See also: HE, HMOD, Section 1.3

Function: **Interpolation**

Type: Assertive, Interrogative

Syntax: INT
INT=[DOT], [DOTJ], [LIN] or [SINE]

Explanation: There are four choices for interpolation on the displayed traces:

1. DOT — Dots only: when in expanded mode these will be quite visible. This mode is called 'OFF' on the display menu;
2. DOTJ — Dot join: the individual dots are joined by faint straight lines. This mode is called 'NORMAL' on the display menu;
3. LIN — Linear interpolation: extra dots are added to make straight lines between the existing sample points;
4. SINE — Sine interpolation: extra dots are added between the existing samples using sine curves of best fit.

Examples: INT=LIN
INT
'INT=SINE' (4070 response)

Notes: *The interpolation modes are particularly useful on expanded traces where the individual samples start to become visible. LIN and SINE 'invent' extra points which were not part of the captured trace and this should be borne in mind when making measurements on expanded traces.*

See also: HE, Section 2.4

Function: **Channel Invert**

Type: Assertive, Interrogative

Syntax: INV1
INV2
INV3 (4074 only)
INV4 (4074 only)
INV*
INV1=[ON] or [OFF]
INV2=[ON] or [OFF]
INV3=[ON] or [OFF] (4074 only)
INV4=[ON] or [OFF] (4074 only)
INV*=[ON] or [OFF]

Explanation: *In its assertive form this command controls whether the channels are displayed in their normal or inverted modes. INV* can be used to control all channels simultaneously, or interrogate them together.*

Examples: INV1=ON
INV*
'INV1=ON;INV2=OFF'

See also: Section 1.2

Function: **LOCK, Hold All Channels**

Type: Assertive, Interrogative

Syntax: LOCK=[ON] or [OFF]

Explanation: When LOCK is asserted all channel traces are held, even if part way through an acquisition. The action of this command is exactly the same as the Hold button on the front panel.

Example: LOCK=ON hold all traces

See also: HOLD, Section 1.5

Function: **Acquisition Mode**

Type: Assertive, Interrogative

Syntax: MODE
MODE=[ROLL], [REFR], [XY] or [PTR]

Explanation: There are four capture modes on the 4070:

1. ROLL Chart recorder mode: the data comes in from the right-hand side of the screen and travels to the left-hand side, even in the absence of a trigger. This is only valid at timebase ranges slower than 20ms/div. At faster ranges REFR and ROLL are indistinguishable.
2. REFR Refresh mode: data is plotted from left to right across the screen, after a valid trigger is received.
3. XY XY mode: Channel 1 is displayed as the X or horizontal part of the trace and Channel 2 as the Y or vertical part. In 4074, Channels 3 and 4 are also displayed as the vertical part.
4. PTR Pre-Trigger Roll: this mode is a combination of ROLL and REFR in that any part of the trace that was captured before the trigger point will behave like ROLL while the rest will be refreshed. In the same way as ROLL, this is only valid on timebase ranges slower than 20ms/div.

Examples: MODE=XY
MODE
'MODE=PTR' (4070 response)

See also: Section 2.4.

Function: **Save Machine Setup**

Type: Direct Action Assertive

Syntax: MSAV1
MSAV2
MSAV3
MSAV4

Explanation: This command provides the same function as the save part of the Save and Recall Setup Menu. When this command is asserted the present machine setup is saved into the specified backup memory.

Example: MSAV1

See also: MSTX*, RCLMS, Section 2.6

Function: **Transmit Machine Setup**

Type: Assertive, Interrogative

Syntax: MSTX1
MSTX2
MSTX3
MSTX4

Explanation: The data sent by this command is a series of numbers that have no decipherable meaning. They can be used to extend the number of saved machine setups. The format of the numbers is controlled by NB and BLL.

Example: MSTX3
'MSTX3= data field ‹cr›‹lf›'

See also: MSAV*, RCLMS, Section 4.6

Function: **Number Base**

Type: Assertive, Interrogative

Syntax: NB
NB=[BIN], [OCT], [HEX] or [DEC]

Explanation: This command specifies the number base used during bulk data transfers. There are four options:

1. BIN Binary: each byte transferred represents the data for one sample. This is the fastest transfer mode. The range is from 00000000B (bottom of the screen) to 11111111B (top of the screen); the centre is given by 10000000B. Not available via RS423.
2. OCT Octal: each data sample is sent as three unsigned octal (base 8) digits. The range is 000O (bottom of the screen) to 377O (top of the screen); the centre is given by 200O.
3. HEX Hexadecimal: each data sample is sent as two unsigned hex (base 16) digits. The range is 00H (bottom of the screen) to FFH (top of the screen); the centre is given by 80H.
4. DEC Decimal: each data sample is sent as a signed decimal number. The range is -128 (bottom of the screen) to +127 (top of the screen); the centre is given by 0. This is the slowest transfer mode.

Examples: NB=OCT
NB
'NB=DEC' (4070 response)

Notes: *The number base defaults to decimal (DEC) on power up and the selected number base is used for transmitted data, the numeric base for receive data is specified in the header of the bulk transfer. Any numbers received outside the range for the chosen number base will generate a service request 103.*

See also: BL, BLL, TRC*A, TRC*B, REFM*

Function: **Probe Gain**

Type: Assertive, Interrogative

Syntax: PBG1
PBG2
PBG3 (4074 only)
PBG4 (4074 only)
PBG*
PBG1=[x1], [x10] or [x100]
PBG2=[x1], [x10] or [x100]
PBG3=[x1], [x10] or [x100]
PBG4=[x1], [x10] or [x100]

Explanation: The sense ring on the input channel BNC's allows the 4070 to determine what kind of probe is connected to the input. There are three possible types: x1, x10 and x100. The command returns the gain of the probe presently connected to the input, unless this command has been used to assert it otherwise. The assertive form is used to tell the instrument what sort of probe is in use when incompatible ones are connected.

Example: PBG1
'PBG1=x10' (4070 response)

Notes: *If no probe is being used or one without the sense output connected then the value returned will be x1.*

See also: RPBG

Function: **Phase Shift**

Type: Direct Action Assertive

Syntax: PH-
PH+

Explanation: When the 'divide by N' function is in use, i.e. trigger modes ADIVN and BGAT–ADIVN, these commands cause the phase of the captured signal to be advanced or retarded. For example, if an input waveform has a repetitive pattern every 17 triggers, divide by N would be set to 17. This would allow the 4070 to capture the same part of the pattern on each acquisition. These commands enable the user to capture other parts of the pattern. PH- takes the previous trigger point and PH+ takes the next one.

Examples: PH-
PH+

See also: TRGMDA, Section 2.3

Function: **Start Plot**

Type: Direct Action Assertive

Syntax: PLOT

Explanation: When this command is received the 4070 will begin a plot on the selected plot output device. In trace mode,the on-screen traces will be plotted. In menu mode, the screen text is plotted, except when dual or single channel analog plot is selected.

Example: PLOT

Notes: *If the plot destination is GPIB, and the plot was requested from the front panel, or RS423, the instrument transmits data in talk-only mode. GPIB device clear will abort the plot. Service request 74 will be generated when the plot is complete.*

See also: PLTMD, PLTGT, PLTR, PLTDST, PLRT, RTPL, Section 1.7

Function: **Plot Rate**

Type: Assertive, Interrogative

Syntax: PLRT
PLRT=[0.005], [0.01], [0.05], [0.1], [0.5], [1], [5], [10] or [EXTERNAL]

Explanation: The two analog plot selections, single channel analog plot and dual channel analog plot, are for use with non-digital plotters. On this sort of plotter the drawing rate is not fixed. This command enables the user to set this rate to one of the values given above (these are in divisions per second).

Examples: PLRT=5
PLRT
'PLRT=0.01' (4070 response)

See also: RTPL, Section 1.7

Function: **Plot Destination**

Type: Assertive, Interrogative

Syntax: PLTDST
PLTDST=[GPIB], [ANSGL], [ANDL], [PRNT] or [SRL]

Explanation: There are five types of plot output on the 4070: GPIB, RS423 (SRL), the internal plotter (PRNT), single channel analog plot (ANSGL) and dual channel analog plot (ANDL). This command specifies which device will be used when PLOT is asserted.

Examples: PLTDST=GPIB
PLTDST
'PLTDST=PRNT' (4070 response)

See also: PLOT, Section 1.7

Function: **Plot Graticule**

Type: Assertive, Interrogative

Syntax: PLTGT
PLTGT=[ON] or [OFF]

Explanation: On the internal plotter and the two external digital plotter modes, GPIB and RS423, it is possible to plot the screen graticule. This will not be drawn on either of the two analog plot modes. This command does not plot anything, it specifies whether the graticule is plotted when the front panel Plot button is pressed or plot is asserted.

Examples: PLTGT=ON
PLTGT
'PLTGT=OFF' (4070 response)

See also: PLTR, Section 1.7

Function: **Plot Mode**

Type: Assertive, Interrogative

Syntax: PLTMD
PLTMD=[AUTO] or [SNGL]

Explanation: On the 4070 there are two plot modes, Auto and Single. In single mode when plot is asserted, either by the front panel button or by the PLOT command, a hard copy of the screen display is made on the selected plotter. In auto mode when plot is asserted, a hard copy of the screen is made on the selected plotter, the instrument performs another capture, makes a further hard copy, etc.

Examples: PLTMD=AUTO
PLTMD
'PLTMD=SNGL' (4070 response)

Note: *There are only two ways to stop the instrument once AUTO mode is asserted: press Abort on the front panel; or send device clear.*

See also: Section 1.7

Function: **Plot Traces Only**

Type: Assertive, Interrogative

Syntax: PLTR
PLTR=[ON] or [OFF]

Explanation: On the internal plotter and in the two external digital plot modes it is possible to plot traces, the graticule and some alphanumerics. When PLTR=ON the graticule and alphanumerics will not be plotted, even if PLTGTON. In analog plot modes PLTR=OFF is an invalid selection. This command determines the format of the plot; it does not plot anything directly.

Examples: PLTR=ON
PLTR
'PLTR=OFF' (4070 response)

See also: PLTGT, Section 1.7

Function: **Recall Machine Setup**

Type: Direct Action Assertive

Syntax: RCLMS1
RCLMS2
RCLMS3
RCLMS4

Explanation: This command recalls one of the backed-up machine setups. These are setups for all the instrument's controls, i.e. attenuator settings, timebase ranges, trigger source and coupling, etc.

Example: RCLMS3

See also: Section 2.6

Function: **Reference Store Transfer**

Type: Assertive, Interrogative

Syntax: REFM1 REFM5
REFM2 REFM6
REFM3 REFM7
REFM4 REFM8
REFM*
REFM1=[Data Field], [TRC1A], [TRC2A], [TRC1B], [TRC2B], [TRC3A], [TRC3B], [TRC4A] or [TRC4B]
REFM2 to REFM8 are identical.

Explanation: The reference trace stores of the 4070 can be transfered to and from the host computer, or set equal to one of the display trace stores. Each store consists of 1008 data samples, the first data sample being from the left-hand edge of the screen and successive samples coming from one position further right each time.

The format of the data field is dependent on the specified block length. If BLL=0 then this will consist of 1008 numbers in the specified numeric base followed by ‹cr› ‹lf› with EOI on the ‹lf›, if asserted. If BLL is non-zero then the data field will consist of a number of blocks of data each separated by ‹cr› ‹lf› with EOI (if selected) on the last ‹lf›.The numeric base of the data is determined by the NB command.

The command REFM* can only be used interrogatively and has the same effect as issuing the commands REFM1 to REFM8 separately. The instrument responds by sending the contents of each store in the selected number base.

It is also possible to copy one of the screen traces into a reference store with this command. The screen traces are referred to as TRC1A, TRC1B, TRC2A to TRC4B.

Examples: REFM1=TRC1A

REFM2
'REFM2=3,25,89,2,..,123,-5,4,6'

Notes: *The format of the transmitted data is the same as the received data. Additional backup stores can be created in the host computer by retaining this data and transmitting it back to the instrument at a later date.*

See also: BL, BLL, NB, TRC*A, TRC*B

Function: **Release**

Type: Direct Action Assertive

Syntax: REL

Explanation: This command has the same effect as pressing the front panel button Continuous.

Example: REL

See also: ARM, Section 1.5

Function: **Reference Trace Horizontal Scaling**

Type: Assertive, Interrogative

Syntax:

RM1HS	RM5HS
RM2HS	RM6HS
RM3HS	RM7HS
RM4HS	RM8HS
RM*HS	
RM1HS=number	RM5HS=number
RM2HS=number	RM6HS=number
RM3HS=number	RM7HS=number
RM4HS=number	RM8HS=number

Explanation: When a reference trace is saved the timebase range, or horizontal scaling, is saved with it. This value can be changed or interrogated with this command. RM*HS allows all the horizontal scalings to be read with one command: its action is the same as issuing the four commands RM1HS to RM4HS. The range is 20ns per division to 20s per division in 1, 2, 5 steps.

Examples: RM1HS=200E-3

RM*HS
'RM1HS=1;
RM2HS=5E-8;
RM3HS=5E-3;
RM4HS=2E-6 ‹cr›‹lf›'

Note: *When the scaling has been changed to a new value, any cursor calculations made afterwards will be based on the new value.*

See also: HSA, HSB, Sections 1.3, 2.0

Function: **Reference Trace Vertical Scaling**

Type: Assertive, Interrogative

Syntax:

RM1VS RM5VS
RM2VS RM6VS
RM3VS RM7VS
RM4VS RM8VS
RM*VS
RM1VS=[-][›] number [~]
RM2VS=[-][›] number [~]
RM3VS=[-][›] number [~]
RM4VS=[-][›] number [~]
RM5VS=[-][›] number [~]
RM6VS=[-][›] number [~]
RM7VS=[-][›] number [~]
RM8VS=[-][›] number [~]

Explanation: When a reference trace is saved the attenuator setting, or vertical scaling, is saved with it. This value can be changed or interrogated with this command. RM*VS allows all the vertical scalings to be read with one command: its action is the same as issuing the commands RM1VS to RM8VS. The range is 2mV per division to 5V per division in 1, 2, 5 steps. In addition to the scaling, there are three other pieces of information that may be specified:

[-] Trace invert
[›] Uncalibrated
[~] AC coupled

Examples: RM1VS=200E-3

RM3VS
'RM3VS=5' (4070 response)

Note: *When the scaling has been changed to a new value, any cursor calculations made afterwards will be based on the new value.*

See also: TRVS*A, TRVS*B, VS*, Section 1.2

Function: **Remote Probe Gain**

Type: Interrogative

Syntax: RPBG*
RPBG1
RPBG2
RPBG3
RPBG4
RPBG5
RPBG6
RPBG7
RPBG8

Explanation: If a trace is stored in a reference memory, this command can be used to determine the probe gain that was in operation when the trace was captured. The command can be used for each of the reference memories 1 to 8 individually, or for all memories by using RPBG*.

Example: RPBG2
'RPBG2=x10' (4070 response)
RPBG*
'RPBG*=x10,x10,x10,x1,x1000,x10,x1, x1000' (4070 response)

See also: PBG

Function: **Rate of Plot**

Type: Assertive, Interrogative

Syntax: RTPL
RTPL=[0.1], [0.2], [1], [2], [10], [20],[100],[200] or [EXTERNAL]

Explanation: The two analog plot selections, single channel analog plot and dual channel analog plot, are for use with non-digital plotters. On this sort of plotter the drawing rate is not fixed. This command enables the user to set the drawing rate in seconds per division.

Examples: RTPL=2
RTPL
'RTPL=0.2' (4070 response)

Notes: *'Rate of Plot' and 'Plot Rate' are reciprocals of each other i.e.*

$$\textit{Rate of Plot} = \frac{1}{\text{Plot Rate}}$$

See also: PLRT, Section 2.7

Function: **Horizontal Shift**

Type: Assertive, Interrogative

Syntax: SHFT
SHFT=number

Explanation: The horizontal or X position of the traces can be set by this command. The range is +/- 6.00 divisions, allowing the ends of the traces to be shifted past the centre of the screen. In its interrogative form a returned value of zero places the traces nominally in the centre of the screen.

Examples: SHFT=-3.14
SHFT
'SHFT=2.71' (4070 response)

Note: *Negative numbers move the traces to the left and positive numbers move them to the right.*

See also: HE, Section 1.3

Function: **Service Request Value**

Type: Interrogative

Syntax: SRQV

Explanation: When an error is generated in the instrument, either through an invalid command being issued or for any other reason, a service request is generated. This command allows the user to ascertain what the error is and then determine its cause. The service requests are listed below:

SRQ No.	Meaning
0	ok
74	completed
81	ETS Acquiring
96	invalid command
99	command buffer overflow
100	selection failure
101	not allowed when local
102	syntax error in parameter field
103	number out of range
104	length error
105	checksum error

Example: SRQV
'SRQV=74' (4070 response)

Note: *The last two service request numbers, 104 and 105, are only generated by errors in bulk transmissions.*

See also: Section 1.7

Function: **Acquisition Status**

Type: Interrogative

Syntax: STAT

Explanation: This command allows the user to determine which stage the instrument has reached in an acquisition. The three states are given below:

Value	State
ARMD	Armed but not yet triggered
TRIGD	Triggered, acquisition in progress
UPDATE	Acquisition Complete, but data not yet transferred to trace store.
STORD	Trace acquisition complete. Data in trace store.

Example: STAT
'STAT=TRIGD' (4070 response)

See also: Section 1.5

Function: **Trigger Delay by Time**

Type: Assertive, Interrogative

Syntax: TDELA
TDELB
TDELA=number
TDELB=number

Explanation: This command allows the present value of the trigger 'delay by time' function for timebases A and B to be read or changed. The minimum time delay is minus 10.24 screen divisions, the maximum is given in the table below. Negative time delays capture events prior to the trigger point (this is called pre-trigger). The amount of pre-trigger is expressed as a percentage, i.e. -98 (98% pre-trigger) places the trigger point on the right-hand edge of the screen and 0.0 (0% pre-trigger) places it on the left-hand edge. Positive time delay settings capture events after the trigger point, and are expressed in seconds. The maximum allowable amount of pre-trigger is 98%. Values greater than 98.0 will default to 98%.

Timebase range	Max. TDEL
20s/div to 0.1ms/div	99.9s
50µs/div to 50ns/div	0.99s
20ns	0.40s

Examples: TDEL=-50
TDEL
'TEL=0.0' (4070 response)

See also: TEVNT, Section 1.4

Function: **Trigger Delay by Events**

Type: Assertive, Interrogative

Syntax: TEVNT
TEVNT=number

Explanation: On the 4070 it is possible to delay the start of acquisition from arm by a number of trigger events. The specified number of trigger events will be required before an acquisition can begin. The range is from 1 to 999999. The selected trigger mode must be: ADIVN, BDELN, BGATA-DELN or BGAT-ADIVN.

Examples: TEVNT=951
TEVNT
'TEVNT=3' (4070 response)

Note: *A trigger event is a valid trigger as determined by the trigger source, coupling, level and slope controls.*

See also: TDELA, TRGMDA, Section 1.4

Function: **Auto trigger mode on or off**

Type: Assertive, Interrogative

Syntax: TGAAUT
TGAAUT=[ON], [OFF]

Explanation: This command allows the auto-trigger circuit of timebase A to be turned on or off. Note that no auto-trigger circuit exists for timebase B.

Examples: TGAAUT=ON
TGAAUT
'TGAAUT=OFF' (4070 response)

See also: TRGMDA, TS*, TSL*, Section 1.4

Function: **Trigger Level**

Type: Assertive, Interrogative

Syntax: TLA
TLB
TLA=number
TLB=number

Explanation: The level controls of the two trigger channels can be set or read with this command. The range is -6.00 to +6.00.

Examples: TLA=3.73
TLB
'TLB=1.45' (4070 response)

Note: *It is not necessarily possible to relate the trigger level to a particular vertical position on the screen display. This is due to the effects of pre- and post-storage shift and the selected trigger coupling.*

See also: **TRGC, TS, TSL, Section 1.4**

Function: **Trace On/Off status**

Type: Assertive, Interrogative

Syntax: TOF*
TOF1A
TOF2A
TOF3A
TOF4A
TOF1B
TOF2B
TOF3B
TOF4B

Explanation: This command can be used to monitor or set the status of the traces. TOF* monitors all traces. Traces can be monitored and must be set individually using the TOFxA and TOFxB syntax, where x is 1, 2, 3 or 4.

Examples: TOF2B=Off
TOF2B
'TOF2B=Off' (4070 response)

Function: **Trigger Coupling**

Type: Assertive, Interrogative

Syntax: TRGCA
TRGCB
TRGCA=[DC], [AC], [ACLP], [ACHP], [DCLP], [TVL] or [TVF]
TRGCB=[DC], [AC], [ACLP], [ACHP], [DCLP], [TVL]

Explanation: On the 4070 there are seven different types of trigger coupling:

Value	Meaning
DC	Direct Coupling
AC	AC coupling
ACLP	AC low pass
ACHP	AC high pass
DCLP	DC low pass
TVL	TV line
TVF	TV frame

It is possible to have any coupling on either of the trigger channels with the exception of TVF which is not available on the B channel.

Examples: TRGCA=TVF
TRGCB
'TRGCB=ACHP' (4070 response)

Note: *B TV triggers are obtained from the A trigger source.*

See also: TL*, TS*, TSL*, Section 1.4

Function: **Trigger Mode**

Type: Assertive, Interrogative

Syntax: TRGMDA
TRGMDB
TRGMDA=[A], [ADIVN], [BGAT_ADELN], [AGATB], [BDELN], [BGAT_ADELN],
TRGMDB=[A], [B], [ADIVN], [BDELN], [BGAT_ADELN], [AGATB], [BGAT_ADIVN]

Explanation: On the 4070 there are eight different trigger modes on each timebase. These represent different ways in which the trigger signals can be processed before they initiate a capture on that timebase. The options are given below:

Value	Meaning
A	A triggers
B	B triggers
ADIVN	A triggers divided by N
BGAT ADELN	B trigger gated by the A triggers delayed by N events
AGATB	A triggers gated by B triggers
BDELN	B triggers delayed by N
BGAT ADIVN	B trigger gated by the A triggers divided by N events

A detailed explanation of the action of these trigger modes can be found in Section 2.3.

Examples: TRGMDA=ADIVN
TRGMDB
'TRGMDB=B' (4070 response)

See also: Section 2.3

Function: **Display Trace Transfer**

Type: Assertive, Interrogative

Syntax: TRC*A TRC3A
TRC*B TRC3B
TRC1A TRC4A
TRC1B TRC4B
TRC2A
TRC2B
TRC1A=[Data Field], [REFM1], [REFM2], [REFM3], [REFM4], [REFM5], [REFM6], [REFM7], or [REFM8]
TRC1B to TRC4B are identical.

Explanation: The display trace stores can be transferred to and from the host computer, or set equal to one of the reference memory stores. Each store consists of 1008 data samples, the first being for the left-hand edge of the screen and each successive one from one position further right each time.

The format of the data field is dependent on the specified block length. If BLL=0 then this will consist of 1008 numbers in the specified numeric base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non-zero then the data field will consist of a number of blocks each separated by ‹cr› ‹lf› with EOI on the last ‹lf›, if asserted.

The commands TRC*A and TRC*B can only be used interrogatively. These are equivalent to issuing the commands TRC1A, TRC2A and TRC1B, TRC2B respectively, the instrument responds with the data from each trace.

Examples: TRC1A=REFM2
TRC*B
'TRC1B=3,20,2,1,0,....,34;
TRC2B=3,50,1,2,....,45,6 ‹cr›‹lf›'

See also: EOI, REFM*, BL, BLL, NB, WIND

Function: **Horizontal Trace Scaling**

Type: Assertive, Interrogative

Syntax: TRHS1A TRHS3A
TRHS2A TRHS4A
TRHS*A TRHS3B
TRHS1B TRHS4B
TRHS2B
TRHS*B
TRHS1A=number
TRHS1B=number
TRHS2A=number
TRHS2B=number

4074 only:
TRHS3A=number
TRHS3B=number
TRHS4A=number
TRHS4B=number

Explanation: When a display trace is stored the horizontal scaling is also stored. This value can be changed or interrogated with this command. The range is 20ns per division to 20s per division in 1, 2, 5 steps. TRHS*A interrogates the scaling of both the A timebase traces and TRHS*B interrogates both the B traces.

Examples: TRHS1A=200E-3

TRHS2B
'TRHS2B=5E-9' (4070 response)

Note: *When the scaling has been changed the results of any cursor calculation will be based on the new value.*

See also: HSA, HSB, Section 1.3

Function: **Vertical Trace Scaling**

Type: Assertive, Interrogative

Syntax: TRVS1A
TRVS1B
TRVS2A
TRVS2B
TRVS1A=[-][›]number[~]
TRVS1B=[-][›]number[~]
TRVS2A=[-][›]number[~]
TRVS2B=[-][‹]number[~]
TRVS3A=[-][‹]number[~] (4074 only)
TRVS3B=[-][‹]number[~] (4074 only)
TRVS4A=[-][‹]number[~] (4074 only)
TRVS4B=[-][‹]number[~] (4074 only)

Explanation: When a display trace is stored the vertical scaling is also stored. This value can be changed or interrogated with this command. The range is 2mV per division to 5V per division in 1, 2, 5 steps. In addition to the scaling there are three other pieces of information that may be specified:

- `-` Trace invert
- `›` Uncalibrated
- `~` AC coupled

Examples: TRVS1A=5

TRVS2B
'TRVS2B=2E-3' (4070 response)

-0.5~ means the trace is AC coupled and invert is on.
›10 means the trace is uncalibrated and the sensitivity is greater the 10V per division.

Note: *When the scaling has been changed the results of any cursor calculation will be based on the new value.*

See also: VS*, Section 1.2

Function: **Trigger Source**

Type: Assertive, Interrogative

Syntax: TSA
TSB
TSA=[CH1], [CH2], [EXTA] or [LINE] (4072 only)
TSB=[CH1], [CH2], [EXTB] or [LINE] (4072 only)
TSA=[CH1], [CH3], [EXTA] or [LINE] (4074 only)
TSB=[CH1], [CH3], [EXTB] or [LINE] (4074 only)

Explanation: On the 4070 there are five different sources for the trigger channels, the two input channels, the two external inputs and LINE. Channel A cannot use EXTB as input and Channel B cannot use EXTA as input. The exception to this is where channel A takes EXTA as input and Channel B is using TV line coupling, TRGCB=TVL. In this case Channel B will be using the same source as Channel A.

Examples: TSA=EXTA

TSB
'TSB=LINE' (4070 response)

See also: TL, TRGC, TSL, Section 1.4

Function: **Trigger Slope**

Type: Assertive, Interrogative

Syntax: TSLA
TSLB
TSLA=[MINUS] or [PLUS]
TSLB=[MINUS] or [PLUS]

Explanation: The trigger slope determines whether the trigger points are generated on the rising (PLUS) edge or the falling (MINUS) edge of the trigger source.

Examples: TSLA=MINUS

TSLB
'TSLB=PLUS' (4070 response)

See also: TL, TRGC, TS, Section 1.4

Function: **On Screen Text**

Type: Assertive, Interrogative

Syntax: TXT*
TXTnumber
TXTnumber="string"

Explanation: The 4070 has 16 lines of 32 characters on the screen. Line 0 is the top of the screen and line 15 the bottom.In addition, it is possible to use inverse video characters. These appear on lines 16 to 31 which are overlayed with lines 0 to 15. Line 16 places inverse characters in the same screen position as line 0 text and line 31 places them in the same position as line 15 text. TXT* is interrogative only and returns all the text presently on the screen. TXTnumber returns the text on line 'number' only. In its interrogative form the string returned always consists of 32 characters. When asserted the string may have any number of characters up to and including 32.

Examples: TXT1="Gould 4072"

TXT4
'TXT4="TEST NUMBER 8"

Note: *If the screen text line is empty then a string of 32 spaces will be transmitted.*

Function: **Vertical Coupling**

Type: Assertive, Interrogative

Syntax: VC1
VC2
VC3 (4074 only)
VC4 (4074 only)
VC*
VC1=[AC], [DC] or [GND]
VC2=[AC], [DC] or [GND]
VC3=[AC], [DC] or [GND] (4074 only)
VC4=[AC], [DC] or [GND] (4074 only)

Explanation: This command allows the input coupling of the input channels to be interrogated or changed. VC* allows all channels to be interrogated together: its action is the same as issuing all commands.

Examples: VC2=AC

VC*
'VC1=GND ‹cr› ‹lf›
VC2=DC' (4070 response)

See also: V G*, VP*, VS*, Section 1.2

Function: **Variable Gain**

Type: Assertive, Interrogative

Syntax: VG1
VG2
VG3 (4074 only)
VG4 (4074 only)
VG*
VG1=number
VG2=number
VG3=number (4074 only)
VG4=number (4074 only)

Explanation: The input channels on the 4070 have an uncalibrated variable gain, with a range of approximately 2.5 to 1. The input range for this command is 1 to 4096, where 1 is the calibrated position with a gain of 1. The transfer function is non-linear; i.e. if VG1=1000 the channel does not have half the gain as when VG1=2000. As the number increases the gain decreases until 4096 when the gain has decreased to about 0.4.

Examples: VG1=2048

VG2
'VG2=1' (4070 response)

See also: VC*, VP*, VS*, Section 1.2

Function: **Vertical Position**

Type: Assertive, Interrogative

Syntax: VP1
VP2
VP3 (4074 only)
VP4 (4074 only)
VP*
VP1=number
VP2=number
VP3=number (4074 only)
VP4=number (4074 only)

Explanation: The vertical position of traces on the instrument can be controlled in two ways: pre-storage shift and post-storage shift. This command controls pre-storage shift; see VPS* for post-storage shift. The input range is +/− 8.5 screen divisions, where zero is nominally the centre of the screen.

If dual timebase mode is selected then both the A and B timebase traces will be shifted by this command.

VP* returns the values of the shift for all input channels.

Examples: VP1=7.65

VP2
'VP2=-4.67' (4070 response)

See also: VPS*, Section 1.2

Function: **Post Storage Shift**

Type: Assertive, Interrogative

Syntax:

4070	**4074**
VPS1A	VPS3A
VPS1B	VPS3B
VPS2A	VPS4A
VPS2B	VPS4B
VPS*A	
VPS*B	
VPS1A=number	VPS3A=number
VPS1B=number	VPS3B=number
VPS2A=number	VPS4A=number
VPS2B=number	VPS4B=number

Explanation: The vertical position of traces on the instrument can be controlled in two ways: pre-storage shift and post-storage shift. This command controls post-storage shift; see VS* for pre-storage shift. The input range is +/- 4.48 screen divisions, where zero is nominally the centre of the screen.

Examples: VPS2B=-3.8

VPS1A
'VPS1A=4.2' (4070 response)

See also: VP, Section 1.2

Function: **Vertical Scaling**

Type: Assertive, Interrogative

Syntax:

4070	**4074**
VS1	VS3
VS2	VS4
VS*	
VS1=[-][›]number[~]	VS3[-][›]number[~]
VS2=[-][›]number[~]	VS4[-][‹]number[~]

Explanation: This command allows the attenuator settings of the input channels to be interrogated or set. The range of inputs is 2mV per division to 5V per division in 1, 2, 5 steps.In addition to the attenuator settings there are three other pieces of information that may be specified:

- `-` Trace invert
- `›` Uncalibrated
- `~` AC coupled

Examples: VS1=5

VS2
'VS2=2E-3' (4070 response)

-0.5~ means the trace is AC coupled and invert is on.
›5 means the trace is un-calibrated and the sensitivity is greater than 5V per division.

See also: TRVS*A, TRVS*B, Section 1.2

Function: **Trace Window**

Type: Assertive, Interrogative

Syntax: WIND
WIND=number1, number2

Explanation: This command is used in conjunction with the block transfer commands. It specifies a window on the trace that will be transmitted next time a block transfer is requested. The range for number1 is 0 to 1006 and for number2 is 1 to 1007, number2 must always be greater than number1. Only the data samples between the two numbers will be transferred, inclusive.

Examples: WIND=1,58

WIND
'WIND=0,1007' (4070 response)

See also: REFM*, TRC*A, TRC*B

---

2. ADVANCED FEATURES

The main body of this section covers the menu system, its structure and how to select the features controllable through it. In addition, all the remaining buttons not covered in Section 1 are described here.

2.0 ADDITIONAL BUTTONS

The Save, Recall and Clear Trace Buttons

These three buttons are used in conjunction with the numeric keys **0** to **9** at the side of the display.

The **Save** button enables the user to save a trace in the non-volatile RAM, a battery backed-up section of memory. When this is done, the 4070 will retain the trace information for three months after power down.

Save Pressing this button calls up the 'Save Trace' menu. Through this it is possible to retain up to eight traces for three months after power down.

When **Save** is pressed, the display is replaced by a short menu. This contains eight lines of text: trace 1A; trace 1B; trace 2A; to trace 4B. Each line of text is aligned with one of the numeric keys. Each active trace has a Gould logo alongside the text. If, for example, you wished to save trace 1B, then you would press the number 5 key as that would be next to that line of text.

Once a numeric key has been pressed, the display will be replaced by a second short menu. This has eight lines of text: memory 1; memory 2; memory 3; memory 4; to memory 8. This is requesting where to place the data. Again, each line is associated with one of the numeric keys. Select which memory you wish to save the trace in by pressing the relevant button.

The trace will now have been saved and the screen will return to displaying the traces.

Note: *When a trace is saved into a memory, the previous contents of this memory will be lost.*

Recall Pressing this button calls up the 'Recall Trace' menu.Through this menu it is possible to re-display any of the saved traces.

When **Recall** is pressed, the display is replaced by a short menu containing eight lines of text: memory 1; memory 2; memory 3; memory 4; to memory 8. Each of these is lined up with one of the numeric keys. If, for example, you wished to recall memory 2, you would press button 2.

When one of the numbers has been pressed, the display will be replaced by a second short menu requesting with which trace to display the data. This has four lines of text: trace 1A; trace 1B; trace 2A; and trace 2B. Each will be in line with one of the number keys, so to select the trace press the relevant number.

The screen will now return to its previous trace display and the requested backed-up memory will now be in the chosen trace (and still in memory).

Note: *When a memory is recalled, the screen trace will not automatically be placed on hold. If the instrument is in Continuous capture mode, the recalled trace could be immediately overwritten.*

Trace on/off Pressing this button calls up the 'Trace on/off' menu. Through this it is possible to remove or display traces on the screen.

When **Trace on/off** is pressed, the display is replaced by a menu comprising eight lines of text referring to the four traces 1A, 1B, 2A and 2B. Each lines up with one of the number keys. If for example you wished to remove or display trace 1A from the display, you would press button 1 which would be next to the text 'trace 1A'.

The Abort Button

This button will perform one of several different functions, depending on the state of the 4070 at the time the button is pressed.

If the 4070 is currently driving either the internal plotter or an external plotter, pressing **Abort** will terminate the plotting cleanly when the plotter has finished the current line or character.

If the 4070 is communicating with a host computer via GPIB(IEE488) or RS423, pressing Abort will terminate communications, causing a change from remote or local lockout to local status leaving the 4070 unaddressed.

Abort also allows you to escape from the Save, Recall and Clear Trace menus.

Other uses of the **Abort** button are described elsewhere in the text, where relevant.

Abort Terminates plotting at the end of the current line or character and terminates I/O communications via GPIB/RS423 returning the instrument to Local. Allows escape from Save, Recall and Clear Trace menus.

2.1 MASTER MENU

Although the menu system controls a considerable number of functions, it is designed to be simple to use. There is one master menu from which all other menus can be obtained with a single button push.

Master Menu Pressing this button calls the master menu onto the screen.

Menu/Trace Pressing this button calls the last used menu onto the screen. A second press returns the screen to the trace display.

Each entry on the master menu is also a menu, each covering one aspect of the 4070. The text is lined up with the numeric buttons 1-8 on the side of the display. To obtain any secondary menu simply press the relevant button.

Status This menu displays information about the present setup and backup memory setups of the instrument.

Trigger This consists of a 'graphical' menu which controls the 4070 trigger system and allows easy setting of the trigger processor.

Display This menu controls how the traces are acquired and in what format they are subsequently displayed.

Help A brief menu giving some information on various aspects of the instrument's operation.

Save and Recall Setup Up to four control setups on the 4070 can be retained in the backup memory for future recall. These save and recall features can be accessed with this menu. The status menu allows the saved setups to be viewed, see above.

Plot The various methods of plotting captured traces can be set using this menu. Once set up, simply press the Plot button on the front panel to produce a hard copy.

I/O Interfaces This menu allows the controllable features of the GPIB and RS423 interfaces to be set. These include such things as the GPIB address and RS423 baud rate.

TV and Special Functions The additional trigger couplings, TV line and TV frame, can be selected through this menu. In addition, the time and date may also be set for use on the plot outputs.

Controlling the Menus

The menus consist of a number of rows of text each of which is in line with one of the numeric buttons at the side of the display. On some of the lines you will notice there are characters in inverse video, these show which option has been chosen. In some cases, where the number of options is large, only the selected one is shown. Again, you will notice that some of the inverse characters are flashing, this indicates the active line. The entry on this line may be changed by the the relevant numeric button or the vertical datum paddle.

Horizontal Datum can be used to select the active line in the current menu. This is in addition to using the numeric buttons at the side of the display.

Vertical Datum can be used to select options on the active line or skip over digits in number entry mode (see later).

2.2 STATUS MENU

This menu allows the horizontal, vertical and trigger settings of the instrument to be viewed. A typical display is shown in Figure 2.2.1.

VIEW SETUP There are five possible setups on the 4070, the four held in the backup store (see Section 2.6) and the current setup obtained from the front panel buttons and paddles. The setup presently being displayed is indicated by the inverse video characters after the words 'VIEW SETUP'.

Examples:

VIEW SETUP CURRENT	The status menu is showing the present instrument setup.
VIEW SETUP 4	The setup in memory number 4 is being displayed.

To view a different setup simply press button number **1.** Each press steps through the five options: CURRENT, 1, 2, 3, and 4. After 4 has been selected a further press will return the choice to CURRENT.

Mode: There are four display modes: Roll, Refreshed, Pre-Trigger Roll and XY. The mode in the displayed setup is indicated by the abbreviations given below:

Roll	Roll
Refreshed	Refr
Pre-Trigger Roll	Pretrig Roll
XY	X-Y

The four modes and how they operate are described under the display menu, Section 2.4.

Channel Sensitivity

The input sensitivity of the input channels is shown in volts per division. The range is 2mV to 5V per division. If add mode is selected, as in the example in Fig 2.2.1, a 'plus' sign is shown after the attenuator range for channel 1. If invert is selected a 'minus' sign is shown before the attenuator range.

Timebases

The sweep rate of the two timebases, TBA and TBB, is shown in s, ms, μs or ns per division. Following this is the trigger 'delay by time' setting. If the time delay is positive this is given in s, ms, μs or ns as appropriate. With negative time delays the figure is given as a percentage of pre-trigger: 0% places the trigger point at the left hand edge of the screen, 50% in the middle and 98% at the right hand edge.

Triggering

Under each timebase line is a short description of how the sweep is started. This is a representation of the trigger configuration diagram in words, see Section 2.3 for more details.

The bottom two lines show the two trigger channels' source, coupling and trigger level settings. The choices of source and coupling are detailed in Section 1.4.

Note: The trigger level cannot be directly related to a position on the screen, so the figure shown is only representative of the trigger level compared with its settable range.

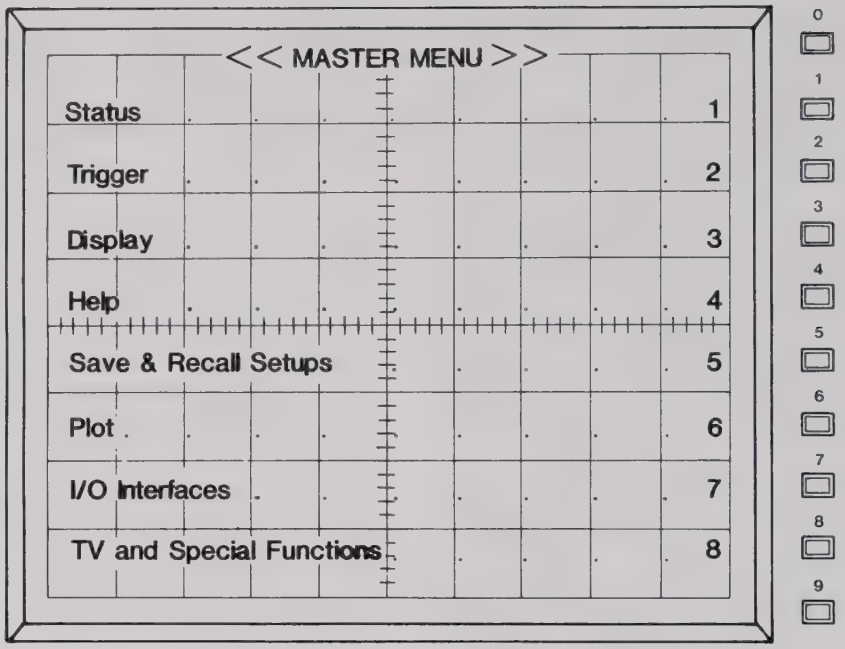


Figure 2.1.1 The Master Menu (4070)

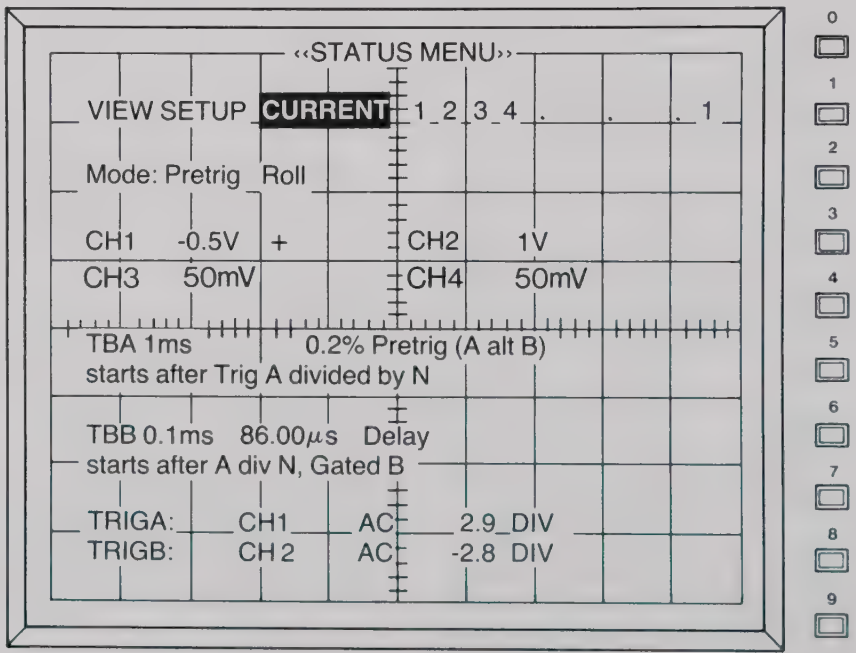


Figure 2.2.1 A Status menu (4071/4072 shown – 4074 is similar)

2.3 TRIGGER MENU

The trigger system on the 4070 is particularly versatile, a graphical representation is used to facilitate ease of setup.

The menu shows two triggers entering at the top, A trig and B trig. These represent the A and B trigger source and coupling combinations. The menu shows how these are processed to initiate the two sweeps, i.e. the A sweep and the B sweep.

The six functions that can be introduced in the trigger paths are described below. At the end of this section is a description of how they may be combined to provide complex trigger functions.

Number Entry in Menu Mode

Certain functions on the trigger menu require numbers to be entered. This is done as follows:

1. The digits are entered one at a time, starting with the most significant one, i.e. the left-hand digit.
2. The digit currently being entered is shown in flashing inverse video.
3. After each digit is entered the next one to the right begins to flash.
4. After all digits have been entered the front panel buttons return to their usual menu control functions.

As an alternative, while the flashing numeral is indicating an 'active' numeric field for delay or events, the appropriate Trigger Delay paddle can be used to alter the value. Once set, Datum should be used to leave the active field.

If **Abort** is pressed at any time during input, number entry is terminated and the feature is de-selected. The last used value is retained, and recalled if the feature is selected again.

A Divided by N

This feature is shown on the menu by the letters:

A ÷ N

The text is in line with the front panel button **2.** If function is already selected then pressing this button de-selects it. When it is not selected the first press of this button selects 'divide by N', the last used value is displayed.The second press puts the menu into number entry mode, see above. The numeric buttons are now used to enter the number N. The range of numbers is 1 to 999999. The value 1 is equivalent to not having the function selected.

In addition, pressing the Trigger Events paddle while in numeric entry mode increases or decreases this number.

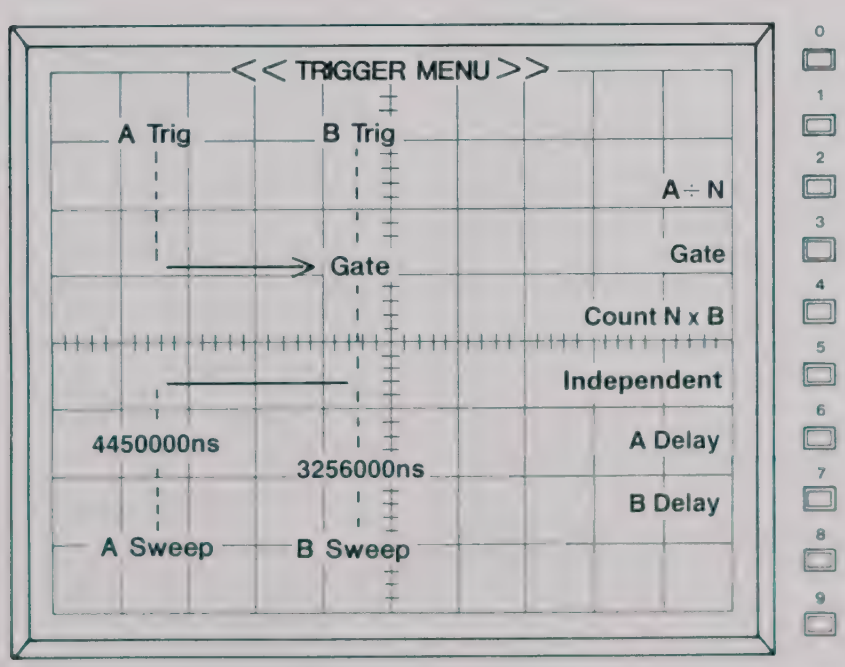
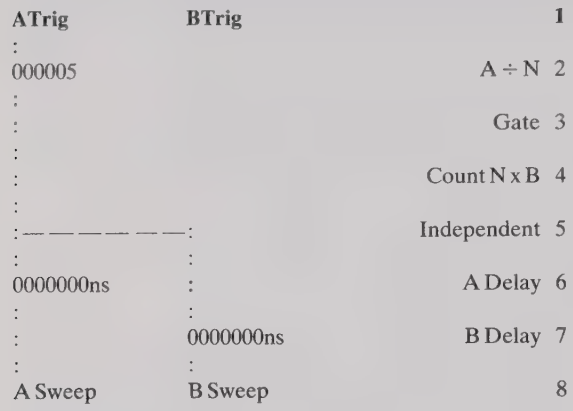


Figure 2.3.1 The Graphical Trigger Menu (4070)

Example: divide by N selected with N=5



Both the A and B sweep are started after every 5th A Trigger. This feature is useful where the input waveform produces a number of triggers but is repetitive only every Nth trigger. A common example of this sort of signal is a video waveform.

The example given above, with N=5, has an input which is repetitive only every five triggers. Setting N=5 will allow successive captures of the same part of the waveform, i.e. it is phase locked, but it does not specify which part, or phase. This is done with the phase advance and retard buttons, or PH+ and PH- on GPIB and RS423.

The phase advance and retard buttons are the numeric button 2 and 3 respectively. These only work when traces are being displayed. They assume their normal menu control functions at other times.

The input wave is repetitive every five triggers, so it must be made up of five phases, all possibly different:

A:B:C:D:E:A:B:C:D:E:.....etc

If phase C is currently being captured, then pressing the phase advance button will enable captures of phase D, whilst still maintaining the phase lock. Similarly, the phase retard button 3 enables captures of phase B in the example above.

Note: *If 'B delay by N' is selected, 'A divide by N' cannot be used, and vice-versa.*

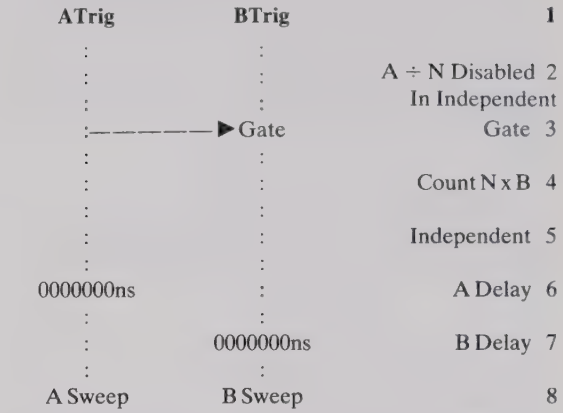
B Gated by A

This feature is shown on the menu by the letters:

Gate

The text is in line with the front panel button 3. Pressing this button selects 'B gated by A', a further press switches it off again.

Example: select B gated by A



The A sweep is unaffected, and a capture is initiated by a valid A trigger after arm. The B sweep is still started by B triggers but a valid A trigger must occur first, i.e.

arm	start the capture sequence
A Trig	A sweep started
arm	continue the capture sequence
B Trig	trigger ignored
A Trig	B trigger gate is opened
B Trig	B sweep started

B delayed by N

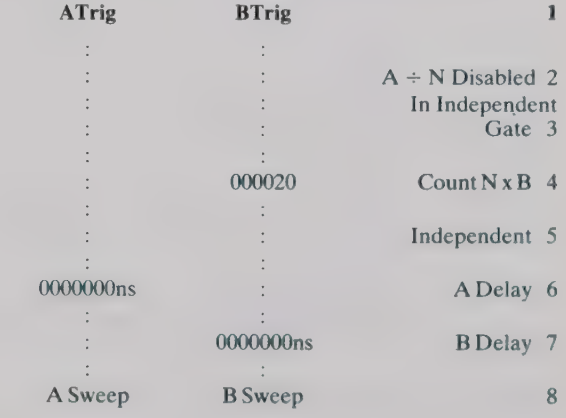
This feature is shown on the menu by the symbols:

Count N x B

The text is in line with the front panel button 4. If the function is selected pressing this button switches it off. When it is not selected the first press of the button selects 'Count N x B', the last used value is displayed. The second press of the button puts the menu into number entry mode, see above. The numeric buttons are now used to enter the number N. This must be in the range 1 to 999999.

In addition, pressing the Trigger Events paddle, while in numeric entry mode increases or decreases this number.

Example: delay by N is selected with a value of 20



The A sweep is unaffected, and a capture is initiated by a valid A trigger after an arm. The B sweep, however, can only begin a capture on the 20th valid B trigger after arm.

Note: *If 'A divided by N' is selected then 'B delay by N' cannot be used, and vice-versa.*
In addition, 'A divided by N' cannot be used with 'Independent' (see below).

Independent

This feature is shown on the menu by the letters:

Independent

The text is in line with the front panel button 5. Pressing this button selects 'dependent', a further press 'Independent'.

Example: select dependent

ATrig	BTrig	1
		A ÷ N 2
		Gate 3
		Count N x B 4
		Independent 5
0000000ns		A Delay 6
	0000000ns	B Delay 7
A Sweep	B Sweep	8

The A sweep is unaffected, and a capture is initiated by a valid A trigger after arm. The B sweep does not use B triggers at all, but will begin the sweep with the same A trigger that started the A sweep.

A Delay by Time

This feature is shown on the menu by the letters:

A Delay

The text is in line with the front panel button 6. When button 6 is pressed to operate 'A delay by time', the display now subtly changes: on the line level with button 4 the units field appears. There are five choices, the selection of which is made by repeated pressing of button **4.** These are:

%	for pre-trigger;
ns	nano-seconds;
µs	micro-seconds;
ms	milli-seconds;
s	seconds.

When the correct units are displayed press button **6** again, this puts the menu in number entry mode, see above. The numeric buttons are now used to enter the delay time. In addition, this number can be entered by the 'Time Delay' paddle: pushing to the left decreases the delay and pushing to the right increases it. See also Section 1.4.

Example: select A delay by time with a delay of 0.5ms

ATrig	BTrig	
		A ÷ N Disabled 2
		In Independent
		Gate 3
		Count N x B 4
		Independent 5
0000500µs		A Delay 6
	0000000ns	B Delay 7
A Sweep	B Sweep	8

The B sweep is unaffected and a capture is initiated by a valid B trigger after arm. The A sweep begins its capture 500µs (0.5ms) after the receipt of a valid A trigger after arm. Negative time delays allow capture of events prior to the trigger point. See Section 1.4 for more details.

B Delay by Time

This feature is shown on the menu by the letters:

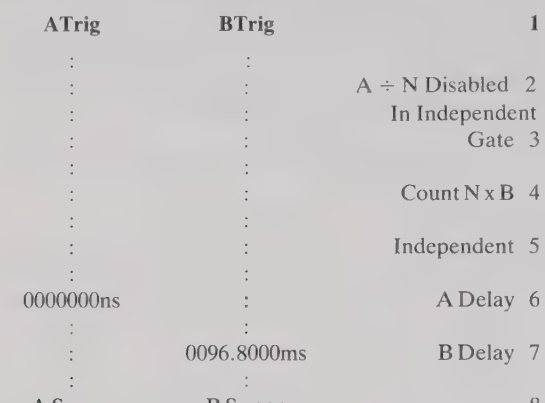
B Delay

The text is in line with the front panel button **7.** When button 7 is pressed to operate 'B delay by time', the display now subtly changes, on the line level with button 4 the units field appears. There are five choices, the selection of which is made by repeated pressing of button 4. These are:

%	for pre-trigger;
ns	nano-seconds;
µs	micro-seconds;
ms	milli-seconds;
s	seconds.

When the correct units are displayed press button **7** again; this puts the menu in number entry mode, see above. The numeric buttons are now used to enter the delay time. In addition, this number can be entered by the 'Time Delay' paddle: pushing to the left decreases the delay and pushing to the right increases it. See also Section 1.4.

Example: select B delay by time with a delay of 96.8ms



The A sweep is unaffected, and a capture is initiated by a valid A trigger after arm. The B sweep begins its capture 96.8ms after the receipt of a valid B trigger after arm. Negative time delays allow capture of events prior to the trigger point.See Section 1.4 for more details.

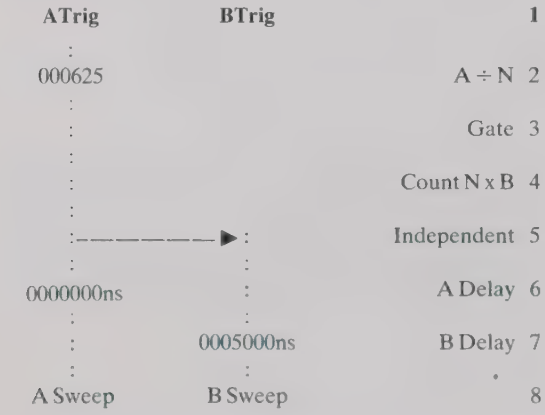
Combining Trigger Functions

The above trigger functions can be freely combined with the following exception:

> 'A divide by N' and 'B delay by N' cannot be used simultaneously;

The trigger menu shows the two trigger channels A and B at the top, with two paths downwards to the two timebase sweeps A and B. A Trig and B Trig are the valid triggers as determined by the source and coupling etc. selections. These pass into the trigger system and are acted upon by the functions outlined above. Eventually, after processing, they emerge to begin the sweeps.

To understand how the sweep is started it is merely necessary to follow the path up to its source. There follow two examples to clarify this.



The input signal for this example could be a PAL A TV signal.

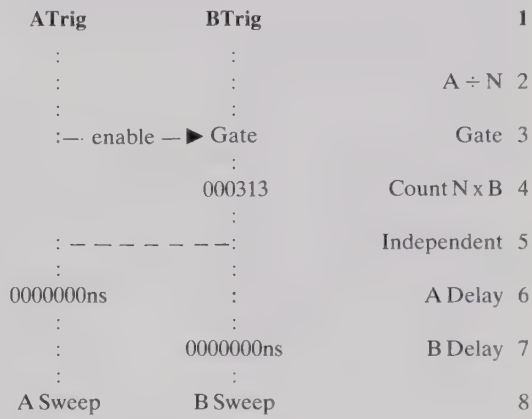
The A Sweep

The A sweep can only be captured on every 625th trigger. If the coupling selection of the A trigger channel were TVL (TV line) then the same TV line would be captured on each acquisition. The line that is captured could be controlled by the phase advance and retard buttons.

The B Sweep

This captures on the same TV line as the A sweep but there is a delay of 5μs before the B sweep begins. This could be showing the rear porch in more detail.

Example no.2



If the trigger coupling is set to TVF (TV frame) and the B trigger to TVL (TV line) then this trigger set-up could be used to display a complete PAL TV field and a selected line. The A timebase should be set to display TV frames and the B timebase to display TV lines. Both sweeps are enabled by the same event.

The A Sweep

The A trigger enables the gate and then 313 B Triggers later the A sweep is triggered. (the 313th line is line 1 of the second interlaced frame).

The B Sweep

The next A trigger enables the gate and then 313 B Triggers later the B sweep is triggered. The next trigger sequence will again trigger an A sweep.

Trigger Output

The 4070 is fitted with a rear panel trigger output at TTL levels via a BNC connector. This provides a pulse at the trigger point of each new acquisition. If a trigger delay facility is used, this event occurs at the end of the delay period.

This output can be used to synchronize other equipment such as additional oscilloscopes or logic analyzers to the 4070.

2.4 THE DISPLAY MENU

This menu can be used to control some of the more advanced features of the oscilloscope, including its 'glitch' or transient detection facilities, and its sophisticated interpolation capabilities.

Timebase Mode

The captures on the 4070 can be realised in a number of different ways. The options available are:

Roll This mode is like a chart recorder: the display scrolls from right to left until a trace has been acquired. This scrolling effect operates on the slower timebase ranges, upto 50ms/div. On the faster ranges there is no discernable difference between Roll and Refreshed.

Refresh This is the more usual oscilloscope mode, imitating the normal timebase of a real-time 'scope. The display is plotted from left to right as it is acquired.

PreTrig Roll This mode is a mixture of the previous two modes. If there is zero time delay or a positive time delay set, this mode acts in the same way as Refresh. Only when there is negative time delay, when we are viewing events prior to the trigger point, does this mode appear different.

All points to the left of the trigger point (i.e. prior to it) will roll from right to left as described above under Roll.They will continue to roll until a trigger is received, at which time the portion of the trace to the right of the trigger point will be refreshed as above, under Refresh.

Example:

TBA = 100ms Pre trig = 30%

The A timebase is set to 100 milliseconds per division and there is minus 300 milliseconds delay, or 30% pre-trigger. This places the trigger point three divisions from the left-hand edge of the screen. All points to the left are pre-trigger and all points to the right are post trigger. If we perform a capture in PreTrig Roll, the first three screen divisions will be seen to scroll until a trigger is received then the right-hand seven divisions will be refreshed. This mode is particularly useful on very slow timebase ranges where the operator can view the 'filling' operation of the pre-trigger stores.

XY In this mode Channel 1 is plotted against Channel 2. Channel 1 takes the X, or horizontal component, and Channel 2 takes the Y, or vertical component. The timebase rate at which the channels are acquired is selectable in the normal manner. (Section 1.3).

Note: The XY display mode is only a display of the captured waveform. The waveform can be viewed in the normal YT mode by selecting refresh. When in X-Y mode, Add is disabled. When in Add mode, X-Y is disabled.

The various choices of timebase mode are made by repeated pressing of the number 1 button, the present selection being indicated by the inverse video characters.

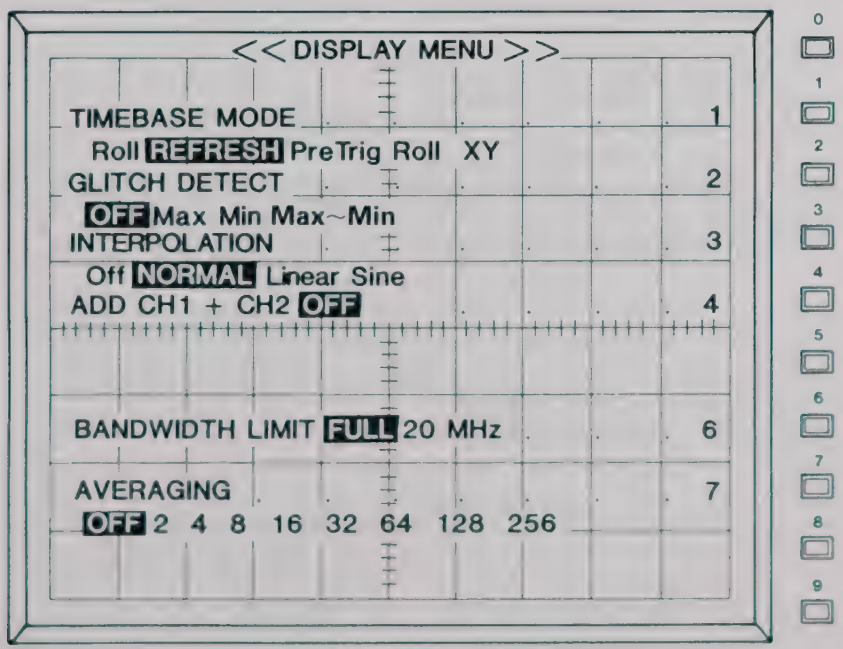


Figure 2.4.1 The Display menu (4071 4072 shown, 4074 is similar)

Glitch Detect

This facitilty allows the user to capture transients, as brief as 5ns, which may occur at any time during the normal sample period. This feature is only available on timebase ranges upto 5us/div. The four options are:

Off No glitch detection

Max Instead of displaying the normal sample point, maxima are detected between the samples and these will be shown instead.

Min Instead of displaying the normal sample point, minima are detected between the samples and these will be shown instead.

Max~Min The 4070 will alternately look for maxima and minima. If there is an alias being displayed, (see Section 1.1) by selecting 'Max~Min' this will be displayed as two horizontal lines, one formed from the maxima and the other from the minima. These two horizontal lines are formed alternately one dot high and one low, i.e. maxima then minima.

Interpolation

Various methods are available for joining the sample points on the screen display: these options are particularly useful with X Mag and at fast timebases.

Off No interpolation will be performed.

Normal The usual dot-joiner will be active: this shows the sample points as bright dots and draws a line between them.

Linear Extra points are inserted between the expanded 'real' sample points. The extra points are placed on an imaginary line joining the true samples. This is the default selection.

Sine Extra points are inserted between the expanded 'real' sample points. The interpolator assumes that the input is sinusoid in content and may add a small amount of preshoot or overshoot on fast squarewave edges.

Other Options

ADD CH1 + CH2 This option adds the inputs of Channel 1 and Channel 2, displaying the results in the Channel 1 traces. The addition is performed prior to any Glitch Detect or interpolation operations.

ADD CH3 + CH4 (4074 only) This option adds the inputs of Channel 3 and Channel 4, displaying the results in the Channel 4 trace. The addition is performed prior to any Glitch Detect or interpolation operations.

Bandwidth Limit The full bandwidth of the 4070 is 100MHz: this option allows it to be reduced to 20MHz when the full bandwidth is not required.

AVERAGING It is possible to improve the signal to noise ratio of the signal by averaging. The 4070 uses continuous averaging and the algorithm used is

$$A_n = \frac{a_n * (f - 1) + d_n}{f}$$

Where:– n = The data point (1 to 1008)
A_n = New value at n
a_n = Old value at n
f = averaging factor (2 to 256)
d_n = Latest value at n

The options for averaging factor are:–

Off (no averaging), 2, 4, 8, 16, 32, 64, 128 or 256.

If Glitch Detect is also selected any non-repetitive glitches will be reduced in magnitude by the effects of the averaging.

When many traces are averaged together the signal to noise ratio is increased by a factor of the square root of the number of averages. For example, if 256 averages were selected the signal to noise ratio would be improved by 16 to one, or 24dB.

NOTE: S/Shot. If Averaging is selected and is pressed the 4070 will capture only 1 sweep with no averaging. Averaging is not available in Roll mode.

To capture and average a fixed number of sweeps is only possible using the optional waveform processor (see section 6).

2.5 THE HELP MENU

This menu comprises five pages of assistance for the user.

2.6 SAVE AND RECALL SETUP MENU

This menu allows the user to manipulate the contents of the four setup memories: new setups can be saved, or already saved setups can be recalled. Recalling a setup does not clear the memory from which it is recalled, but when new setups are saved, the original contents of the relevant memory will be lost.

A setup comprises the following:

1. the attenuator settings;
2. the timebase settings;
3. the trigger source, coupling, slope and level settings;
4. the trigger time and event delay settings;
5. the trigger processor setup;
6. the GPIB and RS423 setups;
7. the default plotter.

To save a setup, select the menu, then choose which memory to store the setup in by pressing the appropriate numeric button (**1** to **4**). The setup will be saved and the old contents of that memory will be lost. To save trace information see Section 2.0.

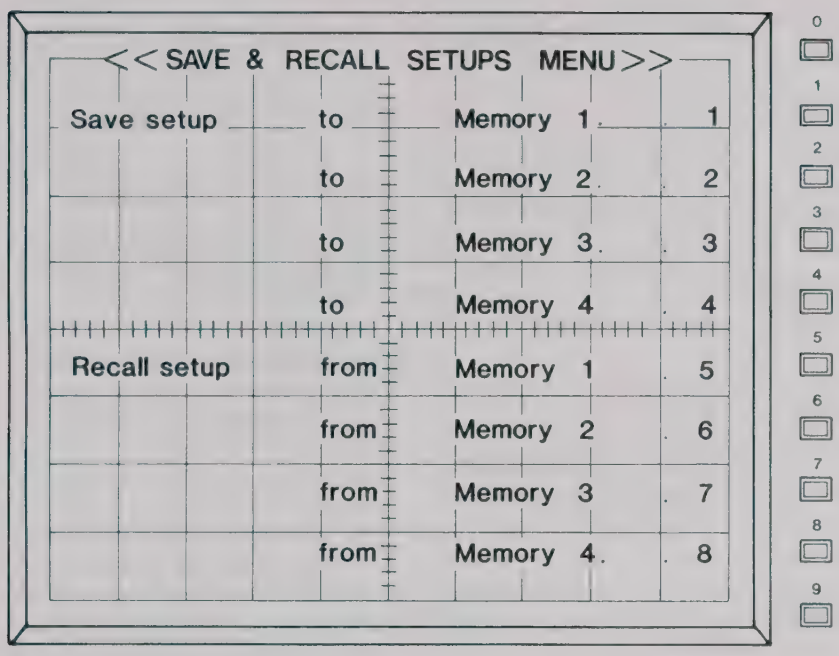


Figure 2.6.1 The Save and Recall Setup Menu (4070)

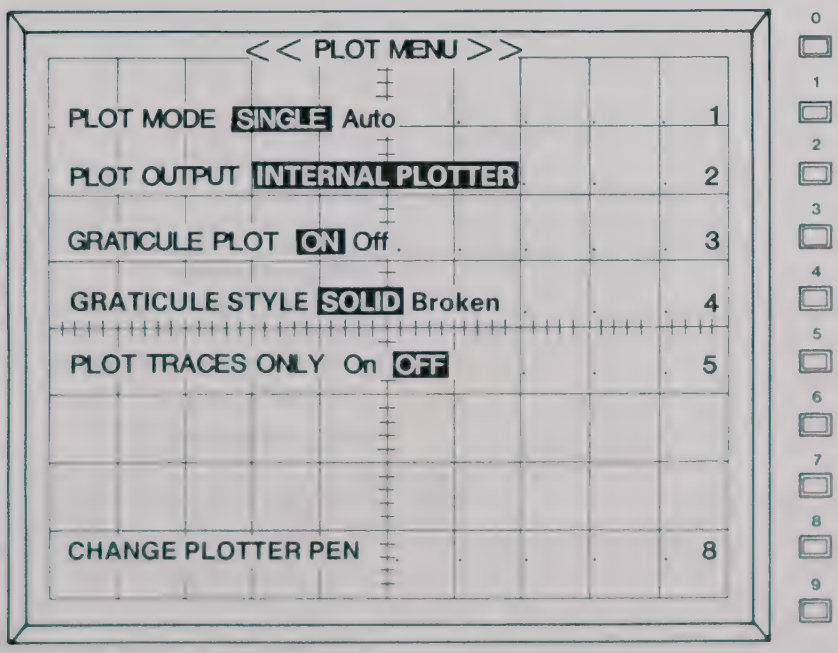


Figure 2.7.1 The Plot Menu (4070)

To recall a setup, select the menu, then choose which memory to recall by pressing the appropriate numeric button twice (**5** to **8**). The oscilloscope will be reset according to the contents of the chosen memory. This operation does not change the memory contents. The recall of traces is done via the **Save** and **Recall** buttons. (see Section 2.0).

To view a setup without recalling it, see the Status menu, Section 2.2.

2.7 THE PLOT MENU

This menu allows the user to set the default plotter option, as follows:

Plot Mode This can be set to either Single or Auto with successive presses of the number **1** button. In Single plot mode one press of the **Plot** button will produce one plot output. In Auto mode, the plotter will instead do successive plots, performing a fresh acquisition between each one. Plotting in this case is terminated with the **Abort** button.

Plot Output Pressing the number **2** button allows the user to set the default plotter. The options are:

1. Internal Plotter;
2. Dual channel analog plot;
3. Single channel analog plot;
4. GPIB plot, talk only;
5. RS423 plot, talk only.

Graticule Plot The user has the option of including the screen grid in the plots with 'On', or excluding it with 'Off'.The grid cannot be plotted with the analogue plot options. See also 'Plot Traces Only' below.

Graticule Style The graticule can be plotted using either Solid or Broken lines as selected using Button **4.**

Plot Traces Only If this option is set 'On', then the alphanumerics and the graticule will be excluded from the plot outputs. This option takes priority over the 'Graticule Plot' option, so the graticule will be excluded if this is set to 'On' even if 'Graticule Plot' is set to 'On' as well. 'Trace Only Plot' is the only permissible option in the analogue plot modes.

Output Rate The user can set the speed of the analogue plots; it can be 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10 divisions per second or set externally by pressing button **6** when an external plotter is selected.

Change Plotter Pen This option is used to change the plotter pen. See section 1.7 for full details of pen changing.

2.8 I/O INTERFACES

This menu allows the user to set a number of standard parameters for the GPIB and RS423 interfaces, if fitted.

GPIB Address The addressing system used by the 4070 is single primary addressing. Pressing button **1** opens a numeric field in which this address can be entered.

Number entry is as follows:

1. Press button **1**.
2. Enter the new address number. Both digits must be entered, most significant digit first. The digit to be entered flashes in inverse video.
3. After both digits have been entered the numeric buttons return to their usual menu controls.

All the other options on this menu are for the RS423 interface:

Speed With this option the user can set the I/O baud rate to 50, 110, 300, 600, 1200, 2400, 4800, or 9600 baud, using successive presses of the number **3** button. The presently selected choice is indicated by the inverse video characters.

Handshake The software handshake XON-XOFF can be turned on and off by successive presses of the number **4** button, with the present selection being indicated by the reverse video characters.

Echo & Prompt All characters sent to the oscilloscope will be echoed back to the transmitting device should the user choose 'On'. When the 'scope is ready to receive the next command it will issue a prompt. If the selection is 'Off' pressing button **5** will switch it on, a further press will switch it off again.

Parity There are three choices: 'NONE' i.e. no parity, 'EVEN' or 'ODD'. The selections are made by repeated pressings of the number **6** button, the present choice being indicated by the inverse video characters.

2.9 TV AND SPECIAL FUNCTIONS MENU

This menu controls a variety of functions, although they are mainly associated with TV triggering. The time and date are only used on digital plots, where they give a record of when the plot was made.

TV Standard

Button **1** permits the selection of the correct line standard. The options are NTSC, PAL and SECAM. This function is not available unless a waveform processor is fitted.

TV Line Number

This enables the **TV Line** number to be set when **TV Mode** capture is selected on the waveform processor. This function is not available unless a waveform processor is fitted. See section 6.

Trigger Coupling

Buttons **3** and **4** allow TV coupling to be selected for the A and B trigger channels. On trigger B TV frame is not selectable. This gives B the choice of TV line plus all the other couplings described in Section 1.4. On A, there is TV frame in addition to TV line, etc.

3 Repeated pressing of this button steps through the choice of trigger couplings: TV line, TV frame and other. AC covers all the other available choices: AC, DC etc. The presently selected coupling is shown in

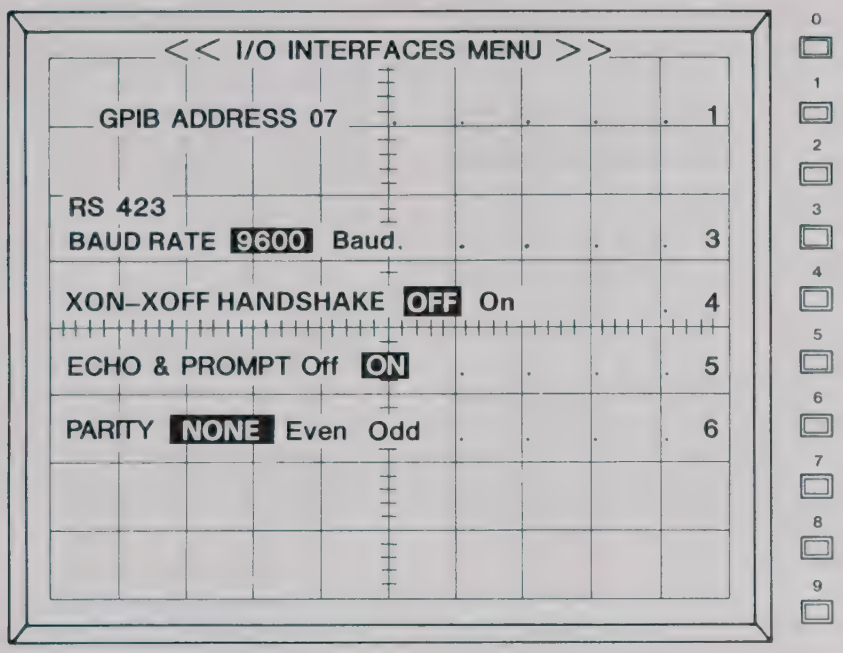


Figure 2.8.1 The I/O Interfaces Menu (4070)

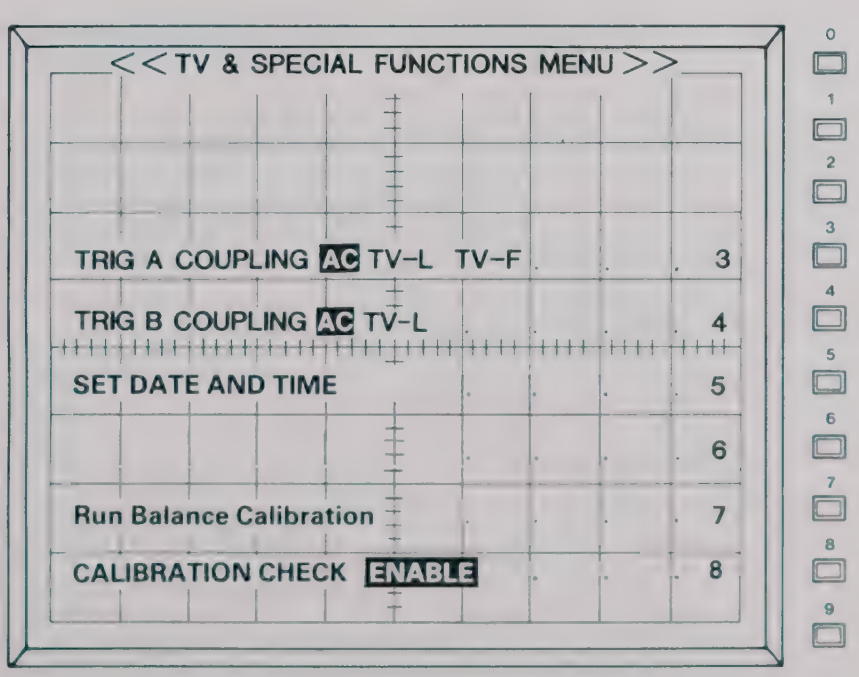


Figure 2.9.1 A TV & Special Functions Menu (4070)

inverse video. You may notice that the LED display showing the trigger source and coupling selections may also change.

4 Pressing this button selects either TV line or 'other' coupling. AC covers all the other choices available from the front panel coupling button, AC, DC etc. The presently selected coupling is shown in inverse video.

Note: *The B TV Line trigger is derived from the A trigger source.*

Set Date and Time

Pressing button **5** displays the Date and Time Menu. Once in this menu, the current date and time when the menu was selected is indicated alongside buttons **2** and **3** respectively.

To change the date or time, press button **2** or **3**. The flashing inverse video cursor indicates that numeric entry is now selected for that field. Enter the digits required. When all the digits have been entered, the flashing cursor will disappear.

The date and time are not altered until button **4** is pressed. To exit from the Date and Time Menu, press button **8**.

Note: *If Abort is pressed during number entry the keys revert to their normal menu control functions.*

Run Balance Calibration

Pressing button **7** will initiate a calibration of the Y preamplifier balance, and will take between 40 to 60 seconds to complete.

This calibration ensures that the DC offsets in the amplifiers are minimized.

This calibration will always take place 15 minutes after the instrument is switched on, and is then available on request.

CALIBRATION CHECK

On the upper timebase ranges, 1ms/div and faster, the 4072 performs a regular alignment check of the acquisition system. This may be disabled if not required.

Enable A re-alignment of the fast timebase ranges is performed every 30 minutes.

NOTE: This realignment is not performed if the 4070 is:

a) Armed waiting for a trigger.

b) In A ÷ N mode.

Disable Re-alignment is inhibited.

3. PERFORMANCE CHECKING

The aim of this section is to allow the user of a 4070 to verify the major analog performance parameters. Should any of these fail to be within specification then it is recommended that the instrument be re-calibrated. A skilled technician with the aid of the service manual should be able to perform this task; alternatively return the instrument to your Gould distributor.

Risetime

Equipment required:

Fast edge generator <1ns: Bradley oscilloscope calibrator type 192 or Tektronix PG506 or similar;
50 Ohm precision coaxial cable;
50 Ohm precision terminator.

Connect the edge generator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable.

1. Select 50mV per division on the input channel and set the timebase to 1μs per division.
2. Set the generator to give 300mV peak to peak at a repetition rate of 1MHz and adjust the trigger level to give a stable trace. Adjust the pre-trigger setting to view the leading edge.
3. Select the cursors and change the timebase to 20ns per division.
4. Apply x20 trace magnification using the X Mag On and X Mag 2>20 buttons, to give 2ns per division, and adjust the horizontal Position paddle to centre the fast edge.
5. Position the cursors on the edge such that the minor cursor is 30mV below the high level and the datum cursors cross 30mV above the low level.

The risetime can now be read from the cursor line on the bottom row of text. This figure should not be greater than 3.6ns.

Bandwidth

Equipment required:

Levelled signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable. On the 4071, only one channel should be turned on.

1. Select 50mV per division on the input channel and set the timebase to 50μs per division.
2. Set the amplitude of the signal generator to give six divisions at 50kHz or similar reference frequency.
3. Change the timebase range to 250ns per division.
4. Increase the frequency on the signal generator until the peak to peak amplitude reduces to 4.2 divisions.

The measured frequency should be greater than 100MHz if bandwidth limit is not selected and approximately 20MHz if it is selected.

Trigger Sensitivity

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable·
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable.

1. Select 50mV per division on the input channel and set the timebase to 50μs per division.
2. Select Auto trigger.
3. Set the signal generator to 50kHz or similar reference frequency and adjust the amplitude to give three major divisions peak to peak. Then reduce the signal by 10:1 to give a signal of about one and a half minor divisions.
4. Select AC **Coupling** and **Norm** on the trigger controls.

It should be possible to find a suitable trigger level to obtain a stable picture.

Trigger Bandwidth

Equipment required:

Levelled signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable. On the 4071, only one channel should be turned on.

1. Select 50mV per division on the input channel and set the timebase to 250ns per division.
2. Select AC **Coupling** and **Norm** on the trigger controls.
3. Set the signal generator to give one major division at 100kHz input frequency.
4. Without adjusting the amplitude set the signal generator to 100MHz.
5. Change the timebase to 250ns per division.

It should be possible to adjust the trigger level to give a stable trace.

Timebase Calibration

Equipment required:

Time calibrator: Bradley oscilloscope calibrator type 192 or Tektronix TG501 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the calibrator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable.

1. Select a suitable timebase range to view the signal and set the channel attenuator to give between two and five vertical divisions of signal.
2. Select DC **Coupling** and **Norm** on the trigger controls.
3. Adjust the trigger level to give a stable trace.
4. Change the timebase to 500ns per division.
5. Set the calibrator to produce markers every 500ns.

It should be possible to align the markers with the vertical graticule lines to within the required specification. In addition, if cursors are called up and placed on identical positions on two markers they should read multiples of 500nS to within the required specification (see appendix).

Note: *If the instrument fails on this specification point it is indicative of a major system fault and it should be serviced immediately.*

Vertical Calibration

Equipment required:

Oscilloscope calibrator: Bradley type 192 or similar;
Coaxial cable.

Connect the vertical calibration output of the oscilloscope calibrator to the 4070 through the coax cable.

1. Set the timebase to 500μs per division and select 2mV per division for the input channel.
2. Set the calibrator to give 12mV peak to peak, i.e. 5 screen divisions.
3. Adjust the trigger level to give a stable picture.
4. Switch the cursors on.

The peak to peak measurement should be 12mV and the trace should be 6 divisions high. For the accuracy of the measurements see the appendix.

Note: *On the more sensitive ranges it is recommended that 20MHz bandwidth is selected to reduce random noise.*

These measurements should be repeated on all the attenuator ranges, each time setting the calibrator to 6 screen divisions for the selected range.

Max-Min (Alias Detector)

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 4070 end of the cable. On the 4071, only one channel should be turned on.

1. Set the timebase to 250ns per division and select 50mV per division on the input channel.
2. Set the generator to give approximately 5 divisions at 10MHz and adjust the trigger level to give a stable trace.
3. Select 200μs per division on the timebase. You should notice that the screen picture will change considerably with small changes in input frequency.
4. Carefully adjust the frequency of the signal generator to produce a sine wave of approximately 2 to 5 cycles. This is an alias.
5. Select Max-Min (see Section 2.4 for details).

If Max-Min is functioning correctly then a five division band will be displayed. If dot join is switched off this display will appear as two roughly horizontal lines. These will be at the peak levels of the input signal.

4. ALPHABETICAL SUMMARY OF THE CONTROLS

Abort Terminates plotting at the end of the current line or character; terminates I/O communications via GPIB/RS423; allows escape from Save, Recall and Clear Trace menus.

A/B TRIGGER This button determines which trigger channel's status is viewed on the LED display and which one is controlled by the source, coupling and other controls in this light area patching of the front panel. The light above the button shows which channel is currently being displayed. When selected in this way the source and coupling buttons will change the setup of the channel.

AC/Gnd/DC These are the available ways an input signal may be coupled into the 4070.

AC This channel input coupling selection is used for rapidly varying input signals. Low frequency and DC components will be removed. Suitable input signals are from 10Hz to 100MHz with a x1 probe and 1Hz to 100MHz with a x10 probe.

Gnd The input signal is not coupled into the instrument. A 0V reference signal is displayed.

DC The input signal is directly coupled into the instrument so all frequency components of the input signal will be displayed. The bandwidth is from 0Hz(DC) to 100MHz (see 'Bandwidth Limit' in Section 2.4).

Alpha Intensity This is used to control the brightness of the characters displayed on the screen.

Arm'd This light illuminates after the **S/Shot** button has been pressed; it will stay lit until either a valid trigger has been received or until the **Continuous** button is pressed.

Auto/Norm In normal mode, trace captures can only occur when a valid trigger input has been received. When Auto is selected, if no valid trigger has been received for some time (about 40ms) the instrument will generate its own trigger and initiate a capture.

Auto Setup This will attempt to arrange the display so that two to five complete cycles of the input signal appear, with the amplitude set so that the height of the trace is roughly two to five divisions. Also, it selects auto trigger to ensure the screen is frequently updated.

A TIME/DIV This is a five position paddle which controls the sweep rate of the A traces. A gentle push causes a small change in the sweep rate, whilst a firmer push will cause a large change in the sweep rate.

B TIME/DIV This is a five position paddle which controls the sweep rate of the B traces. A gentle push causes a small change in the sweep rate, whilst a firmer push will cause a large change in the sweep rate.

Cal The **VOLTS/DIV** paddle steps the attenuator through the discrete calibrated ranges from 2mV to 5V per screen division in 1, 2, 5 steps. With a x10 probe the ranges are 20mV to 50V per division at the probe input. See also **Uncal.**

Continuous This button puts the 4070 in continuous capture mode (i.e. its default state). The sequence **Arm'd,** triggered, **Stor'd** and displayed is carried out and repeated automatically.

Coupling Steps through the available options of trigger coupling. These are AC, ACHP(AC High Pass), ACLP(AC Low Pass),DC, & DCLP(DC Low Pass). After DC has been selected, a further press of the button returns the selection to AC. All the couplings can be used with CH1, CH2 and EXT sources. On line, the input coupling is not selectable.

Cursor One press of this button brings up the cursors on the A trace. Another press moves them to the B trace. A third press of the button switches the cursors off. If only one trace is displayed, the cursors will be called up onto that trace; a further press of the button will de-select the cursors.

CURSOR This paddle moves the minor cursor along the trace - i.e. the minor cursor, when moved horizontally, automatically follows the trace up and down as well.

DATUM The left-hand paddle moves the horizontal (voltage) datum cursor vertically, while the right-hand paddle moves the vertical (time) datum cursor horizontally.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth is from 0Hz(DC) to 100MHz (see 'Bandwidth Limit' in Section 2.4).

Events This paddle controls the 'divide by N' and 'Count N x B' trigger function. i.e. it sets the number of triggers (events) required before a capture is initiated. A gentle push to the left decreases the number of events, a firmer push to the left decreases the number of events at a faster rate. A gentle push to the right increases the number of events, a firmer push increases the number more quickly.

EXTERNAL A This input can only be used as a trigger source for the A trigger channel.

EXTERNAL B This input can only be used as a trigger source for the B trigger channel. When TVLN is selected for B, the B trigger source is the external A trigger input.

Focus Controls the focus of the CRT display.

Gnd The input signal is not coupled to the instrument. A 0V reference signal is displayed.

Hold The Hold button next to the S/Shot button freezes the trace on the screen the moment is is pressed. The Channel Hold buttons freeze the traces of the selected channel. The relevant Hold light will be illuminated. It is not possible to have one timebase held whilst keeping the other one live.

A Pressing this button switches the A light on and off. When the A light is illuminated, the **Position** paddle will add post-storage shift to the A trace.

B Pressing this button switches the B light on and off. When the B light is illuminated, the **Position** paddle will add post-storage shift to the B trace.

Hold & A When these are lit, the held A timebase trace will be shifted by the **Position** paddle.

Hold & B When these are lit, the held B timebase trace will be shifted by the **Position** paddle.

Hold A B When these are lit, the A and B timebase traces will be shifted simultaneously by the **Position** paddle.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen if DC coupling is in use.

Norm The trace is a true representation of the input signal. (See also **Auto/Norm**).

On/Off The channels may be swiched in or out with their On/Off buttons. The three options Off/Norm/Inv are selected sequentially by repeated pressings of the button:

Norm The trace is a true representation of the input signal.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen if DC coupling is in use.

Master Menu Pressing this button calls the master menu onto the screen.

Menu/trace Pressing this button calls the last used menu onto the screen. A second press returns the screen to the trace display.

Plot Pressing this button causes the selected plotter to make a copy of the screen display.

Position The vertical **Position** paddles control the vertical position of the trace(s) for their respective channels. If either of the A or B Post Storage lights is lit, then the **Position** paddles will apply 'post-storage shift' to the relevant trace(s). The horizontal **Position** paddle is used to move the trace to the right and left. The position of the cursors is fixed in relation to the trace and they will move with the applied shift.

Post Storage The Post Storage buttons, **Hold, A** and **B** are used for freezing a trace and determining which traces may be affected by the **Position** paddle:

Power This button is used to switch the oscilloscope on or off, depending on its current state.

Recall Pressing this button calls up the 'Recall Trace' menu. Through this menu it is possible to re-display any of the saved traces.

Save Pressing this button calls up the 'Save Trace' menu. Through this menu it is possible to retain up to eight traces for three months after power down.

Scale Illumination The scale on the screen can be lit or unlit using this control.

Slope +/- This button selects positive or negative slope triggers.

Source Steps through the available options of trigger source. For the 4071 and 4072 these are CH1, CH2, EXT and LINE and for the 4074 are CH1, CH3, EXT and LINE. After LINE has been selected, a further press of the button returns the selection to CH1.

S/Shot This button arms the instrument for a single-shot capture. The **Arm'd** light will be illuminated to show that the button has been pressed.

Step/Var This is used with the **VOLTS/DIV** (volts per division) paddle to set the channel attenuator - i.e. it controls the amount by which the trace is deflected for a given input signal:

Cal The **VOLTS/DIV** paddle steps the attenuator through the discrete calibrated ranges from 2mV to 5V per screen division in 1, 2, 5 steps. With a x10 probe the ranges are 20 mV to 50V per division at the probe input.

Uncal The coarse setting of the attenuator is unchanged, but a variable gain is applied by the **VOLTS/DIV** paddle to the input signal. This has a range of 1 to about 0.4. Thus, with an initial setting of 1V per division, the actual sensitivity of the channel could be set anywhere between 1V and 2.5V per division.

Stor'd This light illuminates on completion of a single-shot acquisition. This is after the instrument has been **Arm'd,** triggered and a trace acquired. The light will stay illuminated until the instrument is re-armed or **'Continuous'** is pressed.

Sweep Repeated pressing of this button cycles through the possible combinations of timebases (A only, A & B alternately, B only). A further press returns the selection to A only, etc.

A A only. Any active channel will produce a single trace on the A timebase setting.

B B only. Any active channel will produce a single trace on the B timebase setting.

A B A and B alternately (i.e. 'dual timebase mode'). Any active channel will produce two traces: one on the A timebase setting and one on the B timebase setting.

Time This paddle controls the 'delay by time' trigger function. Negative times enable pre-trigger events to be captured, positive times allow events after the trigger point to be viewed. A gentle push to the left decreases the time delay; a firmer push causes the delay to decrease at a faster rate. A gentle push to the right increases the time delay; a firmer press increases it at a faster rate. If the delay changes to zero, there will be a long pause before the change continues.

TIME/DIV The two timebases which are available for each input signal are set by the **A** and **B 'TIME/DIV'** paddles. The range is 20s/div to 20ns/div.

Trace Intensity This controls the brightness of the trace. The brightness of the cursors and the trigger level indicator are also adjusted by this control.

Trace on/off Pressing this button calls up the 'Trace on/off' menu. Through this it is possible to remove or display traces on the screen.

Trace Rotate If the trace is not properly horizontal relative to the grid, then adjustment of this control with a small screwdriver should remedy the situation.

Trig'd This lights up when the 4070 is receiving valid A trigger signals at a rate of greater than every 40ms.

TRIGGER DELAY These paddles allow the trigger delay conditions to be set; trace acquisition will only begin after these conditions have been met:

Time This paddle controls the 'delay by time' trigger function. Negative times enable pre-trigger events to be captured, positive times allow events after the trigger point to be viewed. A gentle push to the left decreases the time delay; a firmer push causes the delay to decrease at a faster rate. A gentle push to the right increases the time delay; a firmer press increases it at a faster rate. If the delay changes to zero, there will be a long pause before the change continues.

Events This paddle controls the 'divide by N' trigger function on the A timebase and the number of delayed triggers on the B timebase (as selected by the **A/B** switch). A gentle push to the left decreases the number of events at a faster rate. A gentle push to the right increases the number of events, a firmer push increases the number more quickly.

TRIG LEVEL This paddle controls the trigger level setting.

Uncal The coarse setting of the attenuator is unchanged, but a variable gain is applied by the **VOLTS/DIV** paddle to the input signal. This has a range of 1 to about 0.4. Thus, with an initial setting of 1V per division, the actual sensitivity of the channel could be set anywhere between 1V and 2.5V per division.

VOLTS/DIV This adjusts the volts per division. Pushing the paddle upwards will adjust the sensitivity as far as 5V/div. In the other direction, sensitivity can be increased as far as 2mV per division.

X mag On This button selects X (horizontal) magnification; if it is already selected, pressing again switches it off.

X Mag 2›20 Selects the amount of horizontal expansion applied to the trace. Each press of the button steps the magnification through the settings x2, x5, x10 and x20. After x20, a further press returns the setting to x2. The new timebase setting is displayed each time the button is pressed.

x1 The external trigger signal is coupled directly into the trigger circuitry at the specified 500mV sensitivity (see also x10).

x10 The external trigger signal is increased by a factor of 10 before it enters the trigger circuitry - i.e. a signal ten times smaller will be required to produce the same effect as on the x1 setting (i.e. 50mV sensitivity).

+/- This button selects positive or negative slope triggers. The current selection is indicated by the light above the button. If negative slopes are selected then a single press will select positive slopes and a further press reverts to the negative slopes.

0-9 These buttons are used to select options from the various menus and enter numbers when required. See Section 2 for details.

4070 FAMILY SPECIFICATION

(Unless stated, the specification of the 4071, 4072 and 4074 are identical)

VERTICAL INPUT

Input 4071 - 2-Channels BNC connectors
4072 - 2-Channels BNC connectors
4074 - 2-Channels BNC connectors

Bandwidth
DC: 0 – 100MHz (-3dB)
AC: 4Hz – 100MHz (-3dB)

Bandwidth Limit
20MHz (-3dB)

Sensitivity
2mV/div to 5V/div in 1-2-5 sequence.

Accuracy
±3% of full scale

Variable Sensitivity
2.5:1 range allowing continuous adjustment of sensitivity between ranges.

Input Impedance
1MΩ/20pF

Input Coupling
AC-DC-GND

Input Protection
400VDC or pk AC

Vertical Position Range
±8 div

Auto Scale Factors
Probe tip attenuation factors for x1, x10 or x100 probes are sensed by the oscilloscope, providing the probes have a suitable sensing element.

DISPLAY

CRT
10 x 12cm rectangular. Internal illuminated graticule with 10 x 8 divisions and 5 sub-divisions. Continuously variable illumination.

Display Modes

4071 & 4072:
CH1, CH2, CH1 invert, CH2 invert.
CH1 + CH2, CH1 vs CH2, Reference Traces 1 through 8 (To a maximum of 8 displayed traces)

4074:
CH1, CH2, CH3, CH4, CH1 invert, CH2 invert, CH3 invert, CH4 invert, CH1 ±CH2, CH3 ± CH4, Reference Traces 1 through 8. (To a maximum of 8 displayed traces.)

Interpolation
Selectable either sine, linear or no interpolation

Screen Update Rate
Approximately 30 traces per sec

Trigger Reference
There is an on-screen indicator which shows the location of the trigger level and the trigger point

Readout
Readout characters indicate the current setting of the instrument: vertical sensitivity, timebase and cursor measurements

ACQUISITION SYSTEM

Maximum Single Event Useful Storage Bandwidth
100MHz (using internal sine interpolator)

Maximum Sample Rate
4071: 400M samples/sec when operating in single channel mode at 250ns/div or 200M samples/sec with both input channels. Decreasing with timebase range to 5 samples/sec at 20s/div.
4072 & 4074: 400M samples/sec on each input channel at 250ns/div timebase range decreasing with timebase range to 5 samples/sec at 20s/div.

Vertical Resolution
8-Bits (0.4%)

Record Length
1K word per input channel

ACQUISITION MODES

Refresh Mode
For stored data and display updated by trigger event.

Roll Mode
Stored data and display updated continually prior to being frozen by trigger

Pre-trigger Roll Mode
The stored data is updated continually as per the roll mode in the pre-trigger part of the display. Then the entire display is frozen as in the refresh mode upon receipt of a trigger.

Glitch Capture
Capture of either positive, negative or alternate positive and negative glitches. Typically a 5ns pulse can be captured with 80% confidence. There is a 100% confidence of capture to 95% of amplitude for a 30ns pulse.
Note: Glitch capture only operates on timebase ranges from 5μs/div. to 20s/div.

Averaging
Averaging factor is available from 2 to 256 (in a binary sequence)

NON-VOLATILE MEMORY

Waveforms
A total of 8 waveforms can be stored: any trace can be recalled to the display

Set-Ups
A total of 4 set-ups can be stored in non-volatile memory.

Retention Time

The memory is trickle charged and will last approximately 3 months with the power disconnected.

HORIZONTAL DEFLECTION

Horizontal Display Modes

A, A alt B with A intensified by B, B only, X-Y, Refresh, Roll, Pre-Trigger Roll.

Horizontal Display Accuracy

±3%.

A and B Delayed Sweep Range

20ns/div to 20s/div in 1-2-5 sequence. Sweep speeds faster than 250ns/div use equivalent time sampling (ETS). ETS uses random sampling to achieve pre-trigger.

Horizontal Expansion

The Expansion from x2 to x20 times (in a 1-2-5 sequence) is available on all timebase ranges (except x2 to x10 on 20ns/div). This gives a fastest timebase rate of 2ns/div.

Timebase Sample Accuracy

±0.01%.

Timebase Jitter

Less than ±200ps

Trigger Jitter

20s/div to 250ns/div, ±1% of time/div. (unexpanded) ±500ps.
100ns/div to 20ns/div, ±500ps.

Trigger Delay

The A or B sweep start can be delayed from either Trigger A or Trigger B respectively. The delay can be either negative (pre-trigger), or positive (post-trigger).

Trigger Range

Pre-Trigger -0 to 100% with 0.1% resolution.
Post Trigger –

TIMEBASE RANGE	MAX DELAY
20s to 0.1ms/div	99.9s
50μs to 50ns/div	0.99s
20ns/div	0.4s

Trigger Delay Accuracy

±0.001% delay
±0.1% of timebase range
±1ns

Delay by Events

This will allow the B sweep to be delayed from the A sweep by up to 999,999 events with a maximum trigger frequency of 100MHz

TRIGGER

There are two trigger systems, A and B. Each system has similar specifications.

Trigger A:

Source

4071: CH1, CH2, EXT A, LINE.
4072: CH1, CH2, EXT A, LINE.
4074: CH1, CH2, EXT A, LINE.

Couplings

AC, DC, ACHP, ACLP, DCLP.
TV Line, TV Field 2.
DCLP, ACLP -(‹15kHz)
ACHP -(›15kHz).

Trigger B

Source

As Trigger A except use EXT B.

Couplings

As Trigger A. TV Line taken from A Source.

Slope

Selectable +ve, −ve

Sensitivity

Internal:	DC-10MHz	‹0.3 div.
	10MHz-100MHz	‹1.0 div.
External:	DC-10MHz	‹ 50mV p-p (x10)
		‹500mV p-p (x1)
	10MHz-100MHz	‹100mV p-p (x10)
		‹1V p-p (x1)

Trigger Level

Variable over greater than ±4 divisions.
Level indicated on screen with marker.

External Input Impedance

1MΩ/20pF

External Input Protection

200V DC or pk AC

Trigger Combinations

A and B Timebase can be triggered independently or in any combination of the following:

'A' Trigger only
Trigger after every Nth A event
Triggered on B after every Nth A event
'B' Trigger only
'A' Trigger then after N x 'B' trigger events

Trigger Output

Output Voltage level
Logic 0: 0 to 0.5V
Logic 1: 3.5 to 5.0V

Maximum Output Current
Logic 0: 20mA (sink)
Logic 1: 1mA(source)

Protection: 47R series resistor provides protection against voltages of 0V to +5V for 1 second. Voltages in excess of these may damage the output device.

Typical Pulse Parameters: Logic 0 to Logic 1 transition at trigger point. Output then remains high for at least 2ms.

CURSOR MEASUREMENTS

There is an on-screen measurement cursor which can be allocated to any trace plus horizontal and vertical datum cursors which can be moved to any screen position.

The voltage and time differences between the measurement and datum cursors are automatically displayed.

Time Accuracy
As horizontal specification ± sample interval

Voltage Accuracy
As vertical specification ± 1 least significant digit (LSD)

IEEE-488 INTERFACE (option)

Read and Write Functions
All front panel controls are fully programmable, except:
Trace Intensity Power on/off
Alpha-Numeric Intensity
Scale Illumination
Trace Rotation
EXT A and EXT B, x1/x10 switches

Data can be read from and written to all of the memories. All on-screen alpha-numerics can be read remotely. The controller can display messages on the display in 16 lines of 32 characters each.

Recognised Controller Originated Bus Commands

DCL	Returns Intrument to idle state.
SPE	Enables serial poll.
SPD	Disables serial poll.
GTL	Returns control to front panel switches.
SDC	As DCL but only affects devices configured to listen
IFC	Clears the interface.

IEEE-488 Formal Attributes

SH1	Source Handshake	Complete
AH1	Acceptor Handshake	Complete
TE2	Talker Function	Basic Extended Talker/Listener
LE2	Listener Function	Serial poll
SR1	Service Request	Complete
RL1	Remote/Local Function	Complete
PP0	Parallel Poll	None
DC1	Device Clear	Complete
DT0	Device Trigger	Complete

Operating Modes
Addressable from bus
Talk only in Plot mode

Primary Address:
Selectable from Menu 7.

Data Format
BCD, Octal, Hex, Binary.

Transfer Rate
Approximately 5K bytes/sec in binary mode

RS-423 (RS-232) INTERFACE (option)

Specification
All of the functions available via the IEEE-488 interface are available via the RS-423 interface

Baud Rate
50,110,300,600,1200,2400,4800,9600
selectable via menu.

DIGITAL PLOTTER INTERFACE

The instrument can directly address HPGL format plotters via either the IEEE-488 or RS-423 interface. This plots out either menus or traces. The trace plots will include cursor information, range settings, date and time.

Manual Plot
Plotting of all displayed traces or menus initiated by front panel button

Automatic Plot
On-screen traces are automatically plotted after acquisition prior to automatic re-arming of the trigger system

Color
Different colors are selected for traces and the grid when multicolor plotters are used

Date and Time
This can be set to any value and the plotter then prints the time of signal acquisition

INTERNAL PLOTTER (option)

Direct digital plots to the internal multicolor plotter can be selected by the menu to be in the same format as above.

Plot size
89mm wide by 102mm long (approx)

No. of Pens
4 (disposable roller-ball type)

Speeds
50s per trace (approx)

ANALOG PLOTTER OUTPUT

Analog Dual

4071 & 4072
Simultaneous output of X with Y1 and Y2 outputs

4074
As 4072 followed by output of X with Y3 and Y4 outputs.

Analog Single
4071 & 4072: Individual plot of single Y channel plus X output (allowing 2 channels to be plotted sequentially from the socket)
4074: As 4072, but all 4 channels plotted sequentially.

Plot Rate
10,5,1,0.5,0.1,0.05 div/sec and EXTERNAL clock.

Analog Plot Facilities from 15-Way D-Type Connector

Y Output
100mV/div (±10%)

X Output
100mV/div (±10%)

Pen-Lift
Isolated single pole contact closes from start of command to end of plot cycle

Ext. Plot Clock
‹5kHz

+5V Auxillary Supply
Less than 100mA (22 ohm series impedance)

AUTO PLOT

Indicates a plot at end of acquisition, then re-arms instrument at end of plot.

MISCELLANEOUS

Calibrator
1V pk-pk ±1% at 50Hz to 50kHz depending on A Timebase Range. Time accuracy as for timebase range.

Probe Power
Power connector mounted on the front panel for Gould 10-TC-02 logic probe

POWER REQUIREMENTS

Voltage
90V-260V AC. No switching required between voltage ranges

Frequency
48-440Hz

Power
200W max.

DIMENSIONS

See Figure 5.1 – -mm (approx)

WEIGHT

Net Weight
4071 & 4072: 11.4kg (25lbs) approx.
4074: 12.3kg (27lbs) approx.

Shipping Weight
4071 & 4072: 15.9kg (35lbs) approx.
4074: 16.8kg (37lbs) approx.

ACCESSORIES SUPPLIED

Operating Handbook
Front Panel Cover
Pack of 4 plotter pens } where internal
2 rolls of plotter paper } plotter fitted
Line Cord
4071: 2-off PB36 Probes
4072: 2-off PB36 Probes
4074: 4-off PB36 Probes

OPTIONAL ACCESSORIES

Rack Mount Tray with Slides PN 04094732

Cart TR7 General-Purpose Cart

Protective Carrying Case
PN 04101172 – a strong padded case enclosing the oscilloscope with three thicknesses of material covering the front panel

ENVIRONMENTAL

Temperature
Operating
0°C to 50°C
Specified
15°C to 35°C
Humidity
Tested to IEC 68-2-Ca operating 45°C at 95% RH
Tested to IEC-2-Dd cycling non-operating.
25°C-45°C, 95% RH cycles (144 hours).
Safety
Complies with IEC-348 Cat 1 Standards.

Electromagnetic Interference (EMI)
meets VDE 0871 category A.

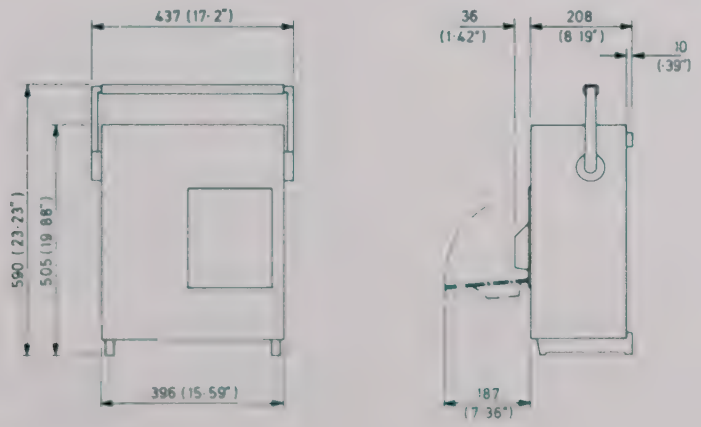


Figure 5.1 Dimensions in mm (in)

WAVEFORM PROCESSOR TYPE 170

Introduction

The 170 Waveform Processor adds a range of functions to the 4070 Family, which increases the power of the instrument in terms of both capture and post-storage analysis and measurement functions.

SPECIFICATION

SIGNAL CAPTURE FUNCTIONS

Signal Averaging
Steps selectable from 2,4,8,16,32,64,128 or 256.

Capture & Repeat
Arms the scope for a signal capture and automatically applies the previously used post-storage functions.

TV Setup TV Line
Configures the instrument to acquire a selected TV Line. (Dependent on Transmission System menu selectable from PAL, SECAM or NTSC.)

Capture
Arms the scope for a single capture.

Limits Testing
This facility allows you to store reference waveforms and create a passband to establish test tolerance if the signal remains within the passband a 'PASS' message will be displayed. Otherwise a 'FAIL' message will appear on the screen.

It provides the option to automatically freeze the input signal should 'FAIL' message result from the test.

POST-STORAGE ANALYSIS FUNCTIONS

Filter
6 selectable stages of low pass filtering per timebase range.

$$\text{Cut-off Frequency} = \frac{15.92}{t_d} \ln\left(\frac{1}{1+\frac{1}{2^n}}\right)$$

t_d = Timebase range in sec/div.
n = Selected filter step.

Restore
Displays trace as if the most recent post-storage function selected was removed.

Trace Magnification/Attenuation
Magnifies trace from 0.06 to 4.00 times in 63 steps selectable by increment/decrement controls.

Invert
Inverts the trace about the voltage datum.

Position Controls
Moves trace and datum in X and Y planes and cursor in X plane.

Integration
Calculates the indefinite integral with respect to the voltage datum and displays the resultant waveform. The trace is auto-scaled.

Area
Calculates the area under a curve with limits defined by the cursor and datum.

POST-STORAGE MEASUREMENTS

Rise/Fall Time
Calculates rise/fall time of a signal; the 0% and 100% points are set by cursor and datum.

Overshoot
Calculates overshoot of a signal as a percentage of setting value. Datum and setting value determined by cursor positions.

Duty Cycle
Calculates duty cycle (ratio of mark to pulse period) as a percentage. Also calculates the average frequency and period of signal. Voltage datum defines the zero crossing or uses the mean of the waveform. Cursor and sdatum set measurement limits.

Pulse Width Calculates time between 50% points (or voltage datum is required). With the pulse 'bracketed' between the time datum and cursor.

Max. Min Displays maximum and minimum voltage excursion of a waveform relative to the voltage datum position. The cursor and datum 'bracket' the waveform of interest.

Peak-Peak Calculates peak-to-peak voltage of the waveform bracketed between the cursor and datum.

RMS Calculates the root mean square (RMS) voltage of a waveform bracketed between the cursor and datum. The values are calculated with respect to both the voltage datum and the mean of the waveform.

ORDERING INFORMATION

4071	2-Channel Digital Oscilloscope
4072	2-Channel Digital Oscilloscope
4074	4-Channel Digital Oscilloscope
102/103	RS423 and IEEE-488 Interface
104	Internal 4 Color Plotter
170A	Waveform processor Type 170A
270	Waveform processor Type 270

PN 04094731 Rack Mount Kit.
PN 04094732 Rack Mount Tray with slides.
PN 04101172 Protective Carrying Case.
Type TR7 General-Purpose Lab Cart.

INTERNAL PLOTTER CONSUMMABLES

PN 04101175 Pack of 4 replacement pens.
One of each color.
PN 04101165 Pack of 8 rolls of paper.

THESE SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

Appendix 1

BRIEF IEEE-488 BUS DISCUSSION

The IEEE-488 bus specification describes an asynchronous byte-serial digital bus sufficiently general to allow instruments with greatly varying capabilities to communicate with each other. Table A1.1 lists the required signals and the assigned connector pins.

In a typical small system, a controller would direct the data transfer and individual operation of a few bussed instruments; for example a 4070 together with printer, and a floppy disc unit, all IEEE-488 compatible. Each of the three instruments would be assigned a unique primary address from 0 to 30. More specific selection of functions within a particular instrument is possible by assigning a unique secondary address to each such function; for example, an 8 channel analog to digital converter might have primary address 5. Each channel could have a separate secondary address from 0 to 7. The instrument (for example the A to D converter) must have been designed to use secondary addressing and the controller must have been programmed to correctly address each instrument and function according to the manufacturer's data before the system can function. Table A1.2 lists all valid IEEE Bus message codes.

All instruments, and the controller(s), in a system are interconnected by a standard connector shown in Fig. A1.3. Commercial examples are the Amphenol series 57 connector or the AMP 'Champ' series.

All bytes of information exchanged on the bus are 'handshakes'. See Fig. A1.1. The sender of a message via the bus is conventionally called the 'talker', and those devices receiving the message are called 'listeners'. The talker (there must only be one at a time) sets DAV LO (data is now valid), the listeners (there may be many) each first set NRFD LO (not ready for more data) and then set NDAC HI (this data byte accepted). After the current byte has been accepted by all listeners, the Talker will reset DAV HI and the listeners will all first return NDAC LO and the NRFD HI, readying the bus for the next byte transfer.

PIN	SIGNAL		DESCRIPTION
1	D101		
2	D102		
3	D103		
4	D104	Data Input/	Carry bi-directional, asynchronous byte serial data, addresses
13	D105	Output lines	or commands
14	D106		
15	D107		
16	D108		
5	EOI		End or Identify. Transmitted by talker at end of multi-byte data record. Used with ATN for parallel poll.
17	REN		Remote Enable. Asserted by controller. Transfers control for each instrument to the bus instead of their front panels.
9	IFC	Interface	Interface Clear. System controller returns all active devices on bus to
		Management	idle states and takes control of bus.
10	SRQ	Lines	Service Request. Line used by device on bus to indicate its need for service from the system controller.
11	ATN		Attention. Asserted by Controller. When true, D101-D108 carry addresses or commands. When false, data.
6	DAV	Handshake	Data Valid
7	NRFD	Lines	Not Ready For Data
8	NDAC	(see Fig. 3.3)	Not Data Accepted
18	(DAV)		
19	(NRFD)		
20	(NDAC)	Return	Twisted with (line)
21	(IFC)	Lines	
22	(SRQ)		
23	(ATN)		
12	Shield		Braid around entire cable, continued through connector shells.
24	Logic Ground		Connects together 0V's of all instruments on bus.

Table A1.1 IEEE Bus Signal Definitions

Table A1.2 IEEE-488 Command and Address Messages

ASCII -- IEEE 488 BUS MESSAGES (COMMANDS AND ADDRESSES) HEX CODES

MSD / LSD	0		1		2		3		4		5		6		7	
	ASCII	MSG	ASCII	MSG	ASCII	MSG [1]	ASCII	MSG	ASCII	MSG	ASCII	MSG	ASGII	MSG	ASGII	MSG
0	NUL		DLE		SP	00	0	16	@	00	P	16		↑	p	↑
1	SOH	GTL	DC1	LLO	!	01	1	17	A	01	Q	17	a		q	
2	STX		DC2		"	02	2	18	B	02	R	18	b		r	
3	ETX		DC3		#	03	3	19	C	03	S	19	c		s	
4	EOT	SDC	DC4	DCL	$	04	4	20	D	04	T	20	d		t	
5	ENQ	PPC	NAK	PPU	%	05	5	21	E	05	U	21	e		u	
6	ACK		SYN		&	06	6	22	F	06	V	22	f		v	
7	BEL		ETB		'	07	7	23	G	07	W	23	g		w	
8	BS	GET	CAN	SPE	(	08	8	24	H	08	X	24	h		x	
9	HT	TCT	EM	SPD	)	09	9	25	I	09	Y	25	i		y	
A	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
B	VT		ESC		+	11	;	27	K	11	[	27	k		(	
C	FF		FS		,	12	<	28	L	12	\	28	l			
D	CR		GS		-	13	=	29	M	13	]	29	m		)	
E	SO		RS		.	14	>	30	N	14	^	30	n		-	
F	SI		US		/	15	?	UNL	O	15	_	UNT	o	↓	DEL	↓

MEANING DEFINED BY PCG CODE

MEANING DEFINED BY PCG CODE

ADDRESSED COMMAND GROUP

UNIVERSAL COMMAND GROUP

LISTEN ADDRESS GROUP

TALK ADDRESS GROUP

SECONDARY COMMAND GROUP

PRIMARY COMMAND GROUP (PCG)

Notes:

1. Device Address messages shown in decimal
2. Message codes are:
   DCL – Devices Clear
   GET – Device Trigger
   GTL – Go to Local
   LLO – Local Lockout
   PPC – Parallel Poll Configure
   PPU – Parallel Poll Unconfigure
   SDC – Selected Device Clear
   SPD – Serial Poll Disable
   SPE – Serial Poll Enable
3. ATN off, Bus data is ASCII; ATN on, Bus data is an IEEE MSG.
   (Hi) (Low)

Appendix 1

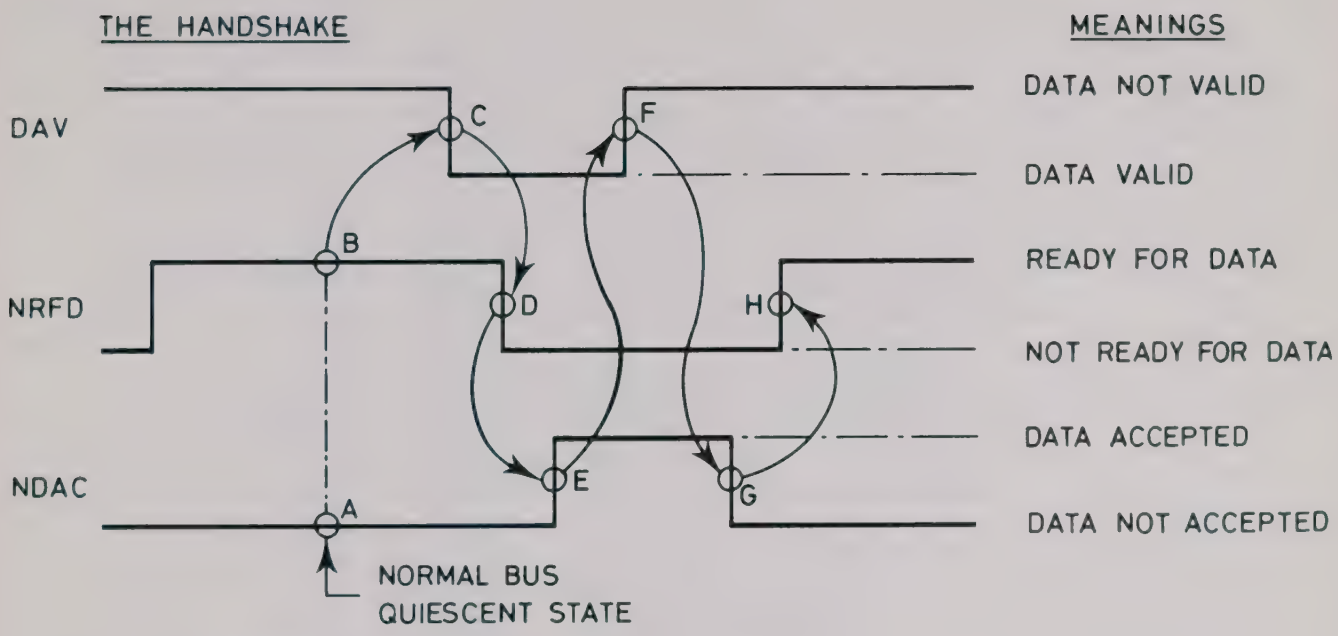


Fig. A1.1 The Handshake

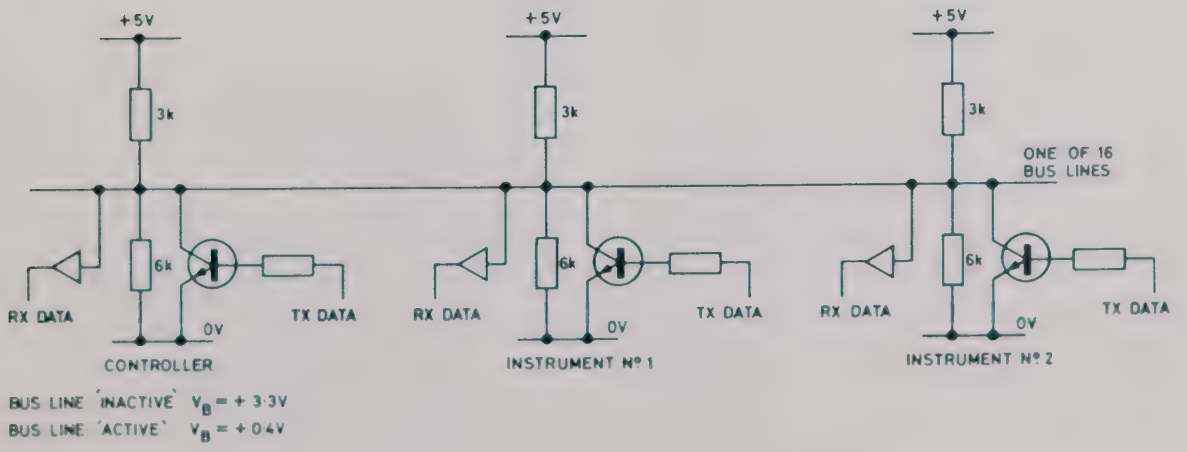


Fig. A1.2 IEEE-488 Bus Lines

Appendix 1

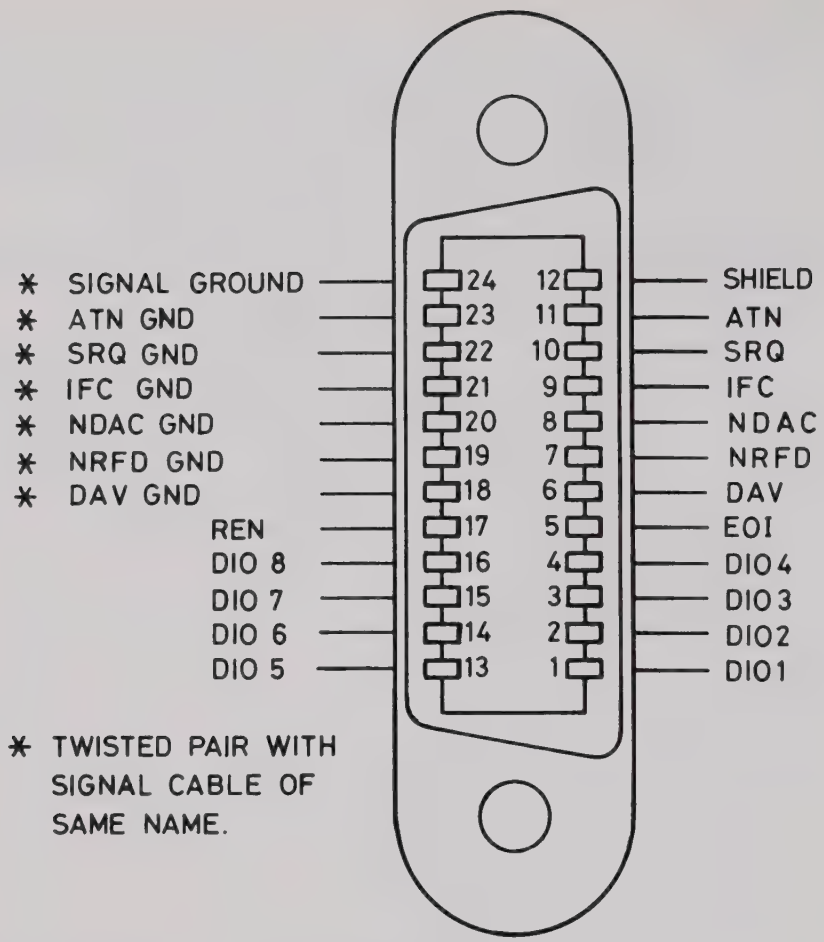


Fig. A1.3 IEEE-488 Connector

Because the bus is asynchronous and a 'wired Or' open – collector configuration is used for each line in the interface, see Fig. A1.2, a handshake line can only change state after all listeners have set their respective drives to the same state. The data transfer rate can only be as fast as that of the slowest receiver.

SERVICE REQUEST (SRQ)

This is a dedicated bus line used by devices to indicate that they need service from the controller (i.e. the opportunity to 'talk').

To establish which device has flagged the SRQ, the controller will use a mechanism called *serial poll.*

SERIAL POLL

This is a special mode set by the controller in addressed listeners causing them, when permitted to talk, to put on the bus their serial poll status word. Bit 6 of this word indicates which device originated the SRQ seen by the controller.

A typical host computer routine for the serial poll would execute the following sequence of events, having sensed the service request (SRQ):

1. Set up a timeout interrupt, so as to deal with those cases of polling a device which is not present;
2. Enter a 'do-loop' of device addresses, and within this:
   a) Send the commands UNLISTEN, UNTALK, MYLISTENADDRESS – this 'silences' the bus and sets the controller to listen;
   b) Command the addressed device to TALK;
   c) Command SERIAL POLL ENABLE (SPE) – this will cause the addressed talker to respond on to the bus with its serial poll status word. Bit 6 of this word indicates whether or not this device originated the service request.
   d) Having read the response, command SERIAL POLL DISABLE, UNLISTEN, UNTALK again and proceed around the loop until the SRQ originator is found.

Appendix 1

FURTHER IEEE-488 INFORMATION:

1. The definitive specification is the IEEE STD 488-1975, Digital Interface for Programmable Instrumentation. Available from:

   IEEE
   345 East 47th Street,
   New York, N.Y. 10017 or,

   American National Standards Institute,
   1430 Broadway,
   New York, N.Y. 10018

2. The corresponding IEC standard is very similar, but specifies a 'D' range connector instead of the 'Amphenol 57' type IEEE connector.

3. A basic discussion of the IEEE-488 bus and an implementation of the standard using the MC68488/MC3448A integrated circuits.

   "Getting Aboard the 488-1975 Bus"
   Available from Motorola Semiconductor Products, Inc.

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